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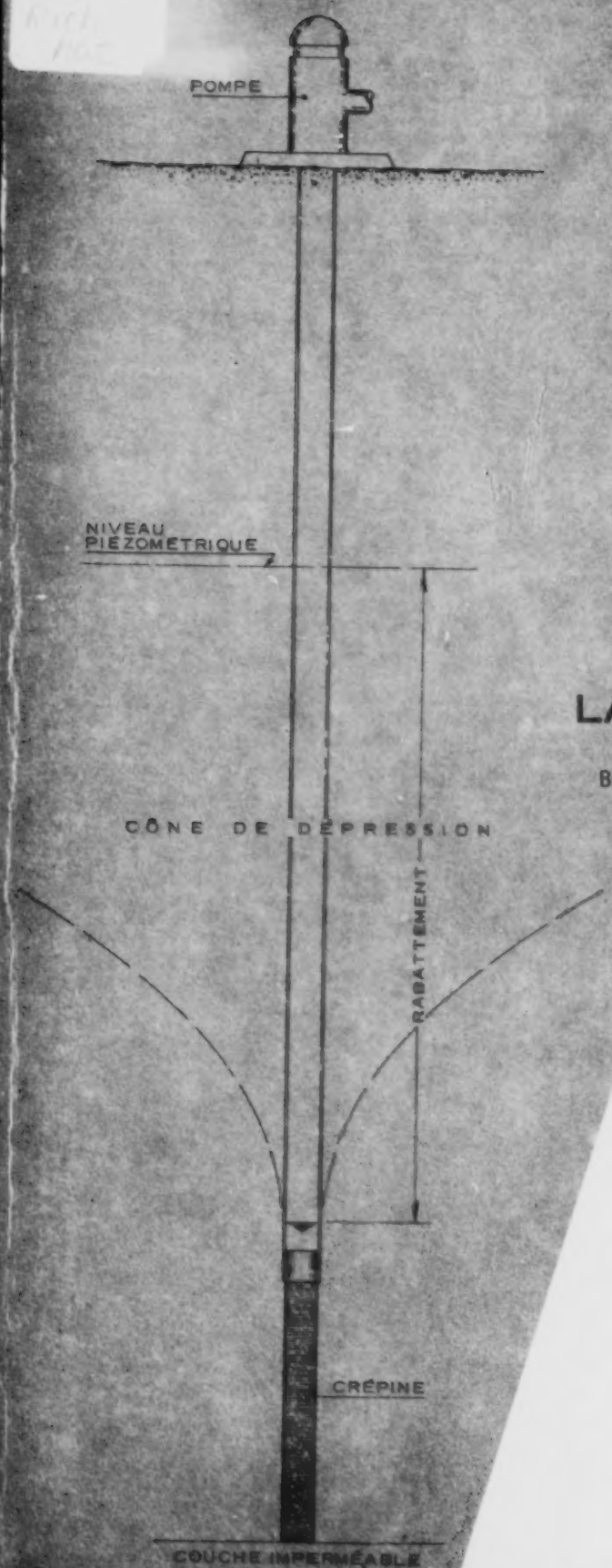

GOVERNMENT
OF QUEBEC

DEPARTMENT
OF NATURAL RESOURCES

WATERS BRANCH

HYDROGEOLOGY
LAKE MASKINONGE AREA

BERTHIER, MASKINONGE AND JOLIETTE COUNTIES

Claude Grenier

UNDERGROUND WATERS SERVICE

QUEBEC 1973

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INTRODUCTION

Purpose of the Study

This hydrogeologic study was begun in 1960 in answer to requests from the municipalities of Saint-Damien and Saint-Gabriel, Berthier County, as well as Saint-Cléophas, Joliette County. At the time, the study involved the determination of the underground water potential of the geologic formations within these municipalities.

Later, a regional organization, the Lanaudière Economic Council, included within its objectives the study of the water supply problems throughout this area.

Finally, in 1970, The Bureau d'Aménagement des Environs de l'Aéroport International de Montréal (BANAIM) undertook an extensive study of a large area including Maskinongé lake.

The purpose of the present study was to accumulate raw data concerning the geology of the unconsolidated deposits and the hydrogeology of this part of Quebec. This report therefore comprises a compilation of drilling results, electric logs, water analyses and other information on the disposition of the underground water.

The large amount of drilling information available, along with that obtained in 1970, has led to an interpretation of the Pleistocene geology of the area in the form of sections as well as isohyp of the bedrock.

Acknowledgments

We would like to thank Robert Denis, of the University of Quebec, who was in charge of a group studying the Pleistocene geology of the Lake Maskinongé area, and who greatly facilitated the interpretation of the geology of the unconsolidated deposits.

Location

The hydrogeological conditions prevailing in the lake Maskinongé area are a reflection of the conditions in a large region encompassing the drainage basins of the Matambin, Mastigouche, Maskinongé and Bayonne rivers. Funds available at the time did not allow us to make a widespread study, so our work

was concentrated within UTM (Universal Transverse Mercator) zone 18, between kilometric coordinates 615.00 and 635.00 East and coordinates 5123.00 and 5140.50 North; the area is covered by the western part of topographic maps 31 L/3 and 31 L/6, at a scale of 1:50,000 (Map 681-A). It can be reached from Joliette, Berthierville and Louiseville by highways 48, 43 or 43A (old numbering system).

Previous reports

The detailed description of the work carried out prior to 1970 has not been included in this report: the reader will find the main reports consulted listed in the bibliography. Most of these were geologic or hydrogeologic reports drawn up following local surveys within the municipalities of the area. Nevertheless, certain points may be summarized:

Climate

This part of Quebec has a climate of the continental, humid, cold type. The mean annual temperature is 40°F. The total annual precipitation is about 40 inches (1016 mm.), of which 25% falls as snow (Table 1).

Topography and Drainage

The dominant topographic feature of the area is the basin of Maskinongé lake, which is centrally located in respect to several large valleys: Matambin to the west, Mastigouche to the north, Maskinongé to the southeast and Bayonne to the south (Map 681-A). The last-mentionned valley is cut off from Maskinongé lake by morainic and deltaic deposits to the south of Saint-Gabriel. The lake itself is at an altitude of 467 feet above sea-level, whereas the average elevation of the surrounding area is about 500 feet.

Geology

The bedrock of the area is of Precambrian age. It is partly covered by unconsolidated deposits made up of clay, mud, sand, gravel and boulders.

TABLE - 1

PRECIPITATION AND MONTHLY MEAN TEMPERATURE
FOR LAKE MASKINONGE AREA

YEAR \ MONTH		JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1967	P	95	44	95	114	75	159	108	108	70	159	95	55
	T	-9	-15	-7	2	8	18	20	18	14	7	-2	-7
1968	P	57	44	111	49	69	76	83	57	44	95	114	121
	T	-14	-13	-3	7	10	16	19	16	16	9	-2	-10
1969	P	95	19	55	115	101	76	121	152	90	58	127	120
	T	-9	7	-3	2	10	17	19	20	13	7	1	-8
1970	P	25	85	50	63	108	60	112	47	102	95	111	67
	T	-16	-11	-4	4	11	17	20	19	12	9	2	-10

P... Precipitation in millimetres
T... Temperature in centigrade degrees

WORK CARRIED OUT IN 1970

Field Study of the Pleistocene

During 1970, a field study of the Pleistocene, led by Robert Denis of the University of Quebec, was concerned with the unconsolidated deposits of the area. Special attention was paid to deposits of glacial, fluvio-glacial and deltaic origin. Sand and gravel pits were examined closely, which work allowed the recent geologic history of the area to be reconstituted. In some places, the depth to bedrock was determined with the aid of a seismic survey. In 1972, Denis wrote a report including a detailed description of the unconsolidated surficial units.

Drilling

Ten bore holes were put down within the unconsolidated deposits, with the use of the rotary drill of the Department of Natural Resources, in order to determine the extent of the water-bearing formations and to facilitate the interpretation of the geologic data. In all, a total of 2,000 feet of drilling was completed. Samples were taken at regular intervals from each bore hole.

Information from the drilling carried out in 1970, as well as from previous work, was transfered to a map at a scale of 1:50,000 (Map 681-C) and recorded in a table (Appendix A). Here, each well and bore hole was identified by a nine-digit number, the first seven digits of which pin-pointed the location on the map. The table contains five columns, from left to right: the identification number, the UTM coordinates, the surface elevation, a stratigraphic description of the material intersected from the surface to the bottom of the hole and, finally, information concerning water level, flow, etc.

Electric Logs

In order to distinguish the contacts between the different units, electric logs were run on all of the holes drilled in 1970. These logs were interpreted by comparison with the driller's log and the corresponding samples. The work was carried out in close collaboration with Robert Denis. Finally, a geologic section was placed opposite the electric log in order to facilitate the interpretation.

All of these logs are included in Appendix B (Figs. 1 to 15). Above each log is the identification number, the UTM coordinate, the number of the topographic map sheet where the well or drill hole was pin-pointed and the date on which the electric log was run. The constituents of the different beds were identified by means of the geological explanations described in the Appendix.

Isohyp Map

With the use of the data gathered in the field, an isohyp map of the bedrock was drawn up (Map 681-D). This map revealed, in addition to the large valleys of the area, a fairly prominent depression trending approximately north-south and cutting the Lake Maskinongé basin as well as the glacio-deltaic barrier which separates it from the Bayonne valley. The low points of this trench are less than 200 feet above sea-level, whereas the neighbouring hills rise to an altitude of as much as 1000 feet.

Geologic Sections

A three-dimensional geologic interpretation is presented in the form of sections in Appendix C (Figs. 16 to 21). The trace of these sections is indicated on the location map (Map 681-C). The control points (drill holes) are represented by two vertical lines topped by an identification number and enclosing symbols representing the geological characteristics of the unconsolidated material intersected. Surface elevations were taken from the 1:50,000 topographic map, except for a few obtained by leveling survey.

Section A (Fig. 16) shows the complete sequence of the unconsolidated deposits of the area. Included are sands and gravels of the Lower and Upper Terraces, deep-water clays of the Champlain Sea, morainic sands, gravels and boulders, well-sorted deltaic sands and gravels, and boulder clays originating from ground moraine and ablation deposits. Of interest are the morainic deposits of the Saint-Narcisse stage, which appear to have been deposited on an elevated portion of the bedrock surface.

Sections 22, 23 and 24 show the pronounced depression in the bedrock which would indicate a north-south drainage trend in the region, toward the present valley of the Bayonne river, during a preglacial period. Bore hole 4922023, within this depression, reached a depth of 140 feet above sea-level without intersecting bedrock.

Chemical Analysis

Method: Within the framework of the hydrogeologic study, 13 water samples were taken (Map 681-C) and analyzed in order to determine the main chemical constituents (Appendix D, table and graphs, Figs. 22 to 33).

Underground waters can be classified through several methods, mainly involving the graphic representation of analysis. The classification of "Souline" according to the ratios

$$\frac{rNa - rCl}{rSO_4} \quad \text{and} \quad \frac{rCl - rNa}{rSO_4},$$

as well as the semi-logarithmic representation of Schoëller using rCa, rMg, rNa, rK, rCl, rSO_4 and $rHCO_3+CO_3$ ions expressed in milliéquivalents par litre (me./l.)*, was employed, as these methods showed more clearly the differences and similarities among analysis.

For each analysis, the pH and Kr values were calculated in order to determine the degree of $CaCO_3$ saturation of the water; the $CaSO_4$ saturation was also evaluated

The following ratios

$$\frac{rSO_4}{rCl} \quad \frac{rMg}{rCa} \quad \frac{rNa}{rMg},$$

the base exchange index (B.E.I.)

$$\frac{rCl - rNa}{rCl}$$

and the phenomenon of sulphate reduction were used to determine qualitatively the movement of underground water in the Matambin River valley.

---

* Atomic or molecular weight of an ion divided by the ionic charge.

Classification of the Water

Following the method of Souline, the 13 analysis were assigned to the following four groups:

Group	Sample No.
$\frac{rNa - rCl}{SO_4} < 1$ Sodium sulphate waters	10 and 11
$\frac{rNa - rCl}{rSO_4} > 1$ Sodium carbonate waters	5, 7, 7A, 8 and 9
$\frac{rCl - rNa}{rMg} < 1$ Magnesium chloride waters	2, 3, 4 and 1A
$\frac{rCl - rNa}{rMg} > 1$ Calcium chloride waters	1

None of the samples analyzed were saturated in $CaSO_4$. However, calculations made by means of the Schoeller diagram allowed us to differentiate waters deficient in $CaCO_3$ from those which were saturated.

I) Deficient: No. 1A, 3, 4, 7, 8, 10 and 11

II) Supersaturated: No. 1, 5, 7A and 9

III) Normal: No. 2

The base exchange index can be read directly from Schoeller's semi-logarithmic graph (right-hand curve linking the Na and Cl ions). It can be either positive or negative.

I) B.E.I. positive: No. 1, 1A, 3 and 4

II) B.E.I. negative: No. 2, 5, 7, 7A, 8, 9, 10 and 11

Water movement

The geochemical study of an area is often useful in following the movement of underground water in the various aquifers. For a given aquifer, this movement is shown by a change in the predominant ions from the recharge zones toward the natural outlets. The recharge zones are usually characterized by water in which bicarbonate is predominant. Sulphates are characteristic at a distance from the point of recharge and, finally, the water is rich in chlorides near the outlets or discharge zones.

The small number of analyses available prevented us from pursuing this aspect of the geochemical study, except in the valley of the Matambin river. Here, samples No. 11, 10 and 1 indicate the presence of a single aquifer, recharged above Saint-Damien and having an outlet at the mouth of the Matambin river. Going downstream, the water changes from sodium sulphate (No. 11 and 10) to calcium chloride (No. 1). At the same time, the chloride content changes from .01 to 3.85 me./l. and the water changes from being $CaCO_3$-deficient (Nos. 11 and 10) to become somewhat scaly (No. 1).

Potability of the Water

To determine the chemical quality of the underground aquifers of the area as far as drinking water is concerned, the different analyses of Appendix D can be compared with the world-wide standards, as shown in Table 2.

TABLE 2

Standards of Water Potability

Determination	Permissible concentration in mg/l except*	Possible effects from excessive use
Turbidity*	10 U.T.J.	Appearance
Color *	20 Hazen units	Appearance
Taste and odor	none	Appearance
Lead	0.1	Toxic (accumulation)
Fluor	2.0	Moltening of teeth
Arsenic	0.05	Toxic
Selenium	0.05	Toxic
Barium	0.0	Toxic
Chromate	0.0	Toxic
Heavy metals	0.0	Toxic
Copper	3.0	Possible physiological effects
Iron and Manganese	0.3	Appearance (on clothing)
Zinc	15.0	Possible physiological effects
Magnesium	125.0	Laxative
Sulfates	250.0	Laxative
Chlorides	250.0	Laxative
T.D.S.	1000	Laxative
Phénols	0.001	Taste
pH	10.6	Laxative
Alkalinity	depend on pH	Laxative
Total hardness	36-100	Excessive soap consumption

- World wide accepted standards for water.

It can be seen that the underground water in the aquifers of the Lake Maskinongé area can, in general, be used as drinking water without any treatment. In a few samples, however, analysis showed that certain substances were present in above-normal concentrations.

The "colour" (sample No. 11), as well as iron content (sample No. 4), provides good indications of prevailing conditions in the water-bearing horizons. The water analysis from an experimental bore hole put down by the Department of Natural Resources below Saint-Damien (4928022) showed an iron concentration of about 1.0 mg./l.

In general, the underground water of the Matambin valley is hard (sample No. 10), except for certain zones of the aquifer which are in direct hydraulic contact with the river.

Another experimental bore hole of the Department of Natural Resources, to the northeast of Saint-Cléophas (5819008), showed excessive concentrations of fluorine. The content seemed to vary from 4.0 to 12.0 mg./l., depending on the intensity of pumping. It should be noted that such a concentration of fluorine in the water could cause physiologic problems if the water is consumed on a continuous basis.

HYDROGEOLOGY

Water Cycle

Water of precipitation falling on the continents can complete its terrestrial cycle in three different ways. It can (1) evaporate before actually reaching the surface or, influenced by the force of gravity, it can (2) run off toward the rivers and eventually into the sea, or, again, it can (3) slowly infiltrate the soil to form part of the saturated zone of "underground water". This water then circulates through the permeable geologic formations, eventually finding a natural outlet.

The proportion of the three components of the cycle (run-off, infiltration, evaporation) depends on the geologic, topographic and climatic conditions of the area as well as the vegetation cover. It is obvious that run-off is dominant on a steep slope over a clay surface, whereas a more level terrain underlain by sands and gravels favours infiltration.

The importance of the loose granular deposits in the Lake Maskinongé area has been noted. Whether occuring at surface or at depth, these deposits are of considerable interest from a hydrologic point of view because they constitute a favorable milieu for the accumulation and circulation of underground water; they can rightly be considered as excellent aquifers from which to obtain appreciable quantities of water.

Therefore, part of the total precipitation, which is about 40 inches (1016 mm.) per year in the area under study, infiltrates the surficial materials, at varying rates of speed, to form part of the underground water-bearing horizons. This infiltration is a function of the porosity and permeability of the surficial deposits. Laboratory tests* on samples taken from the Saint-Gabriel-de-Brandon area showed that the average porosity of the surface sands and gravels was of the order of 40% and the permeability 73 x 10^{-4} cm./sec.

Hydraulic Balance

In practice, the total quantity of water circulating in an aquifer, whether derived by vertical infiltration or as a contribution from neighbouring hydrogeologic units, can be roughly calculated from meteorologic data and from variations in the outflow of the rivers cutting the aquifer. A hydraulic balance test for 1965, based on data obtained from the Maskinongé River basin (396 square miles at the measuring station at Sainte-Ursule), resulted in the calculation of the following annual parameters (cubic feet x 10^{10}):

(1)	Total precipitation falling on the basin.....	3.84
(2)	Actual evapotranspiration.....	1.82
(3)	Drainage by the river.....	2.05
(4)	Variation in the underground water reserves (1) - [(2)+ (3)] ...	-0.03**
(5)	Effective infiltration.....	1.16
(6)	Run-off (1) – [(2) + (5)]	0.86
(7)	Infiltration due to the melting of snow.....	0.05
(8)	Contribution of underground water to drainage (5)— (4)	1.19

For the year 1965, the contribution to the recharge of the water-bearing horizons was positive in April, May, September, October and November, but negative in July; the latter case represents a deficiency in the water supply.

---

* Tests carried out at McGill University.

** The negative value indicates a depletion of reserves.

Hydrogeologic Interpretation of the Data

We could calculate the hydraulic balance of the Lake Maskinongé basin for several different years in order to obtain more accurate values for the parameters outlined above; nevertheless, we believe that the example given is sufficient for the present report. In fact, the accuracy of a hydraulic balance may be verified by measuring, in the field, the variation in the reserves of the water-bearing horizons as reflected by variations in the level of the piezometric surface. Unfortunately, such water level measurements were not carried out systematically during our study because of the lack of an adequate network of piezometers.

Conscious of this lack, we undertook the study of each known (or possible) aquifer in the area in order to determine its hydraulic characteristics and its size.

Known Aquifers

Work carried out in the Lake Maskinongé area prior to 1970 resulted in the definition of three aquifers.

Saint-Gabriel Aquifer

The Saint-Gabriel aquifer, in the municipality of the same name (Figs. 16 and 19), is between 120 and 150 feet beneath the surface. Belonging to a sand-gravel facies of the Champlain Sea, it is made up of beach sediments from the beginning or end of the marine transgression.

The underground water is subject to fairly strong artesian pressure, and it is possible that the aquifer is hydraulically linked to the permeable morainic-deltaic deposits on surface.

The horizon now tapped for the water supply at Saint-Gabriel is not homogeneous; rather, it is made up of an interstratification of sand and gravel beds of differing granularity and permeability.

In 1966, an experimental well was sunk by the International Well Supply Company (IWS) near the municipal water supply. A 24-hour pumping test, at an average rate of 330 gallons per minute (g.p.m.), provided a means of comparison between the behavior of the aquifer and the classic mathematical model developed by C.E. Jacob. In this way, we were able to determine a coefficient

of transmissibility of about 10,000 gallons per day per foot (g.p.d./ft.). In the report which describes this test, we note that the observation wells used to measure the fluctuation of the piezometric surface were not all of the same aquifer horizon as the pumping well. In addition, it was noted that the piezometric level of several wells could not be determined because of the strong artesian conditions which prevailed. Finally, it would appear that the barometric efficiency of the aquifer was not taken into consideration in the interpretation of the data.

Because of these factors, it is quite possible that the shape of the curves on the various semi-logarithmic graphs used to interpret the pumping data is not entirely representative of the existing hydrogeologic conditions.

On the basis of geologic data alone, as well as on current exploitation of this aquifer, it would appear that the actual transmissibility should be higher. Because of its heterogeneity, it is more than probable that the aquifer is influenced by hydrogeologic barriers which further tests should be able to identify.

Matambin Aquifer

This aquifer extends beneath the clay of the Matambin River valley, between Saint-Damien and Maskinongé Lake. The thickness of the permeable zone appears to be quite variable; where penetrated by drilling, it is less than 30 feet. To the east of Saint-Damien, the top of the aquifer is at a depth of 40 feet below surface. It is probable that this depth increases in the direction of the outlet of the Matambin river.

Near bore hole 4928019, where Route 43 crosses the Matambin, the valley narrows considerably to form a gulley only a few hundred feet wide.

In the vicinity of Saint-Damien, a seismic survey revealed the presence of what appears to be an old buried river bed.

A longitudinal section of the valley (Section F, Fig. 22) would indicate that, between bore holes 4928022 and 4928003, the aquifer has the form of a delta deposited by the predecessor of the actual Matambin river during the time of the Champlain Sea.

A 48-hour pumping test, in an experimental well put down about 1 mile below Saint-Damien, provided a means of comparison between the aquifer and

the classic mathematical models and allowed us to calculate a transmissibility of about 2,500 g.p.d./ft. and a storage coefficient of 0.002. It was also possible to determine that for each 100 gallons of water taken from the experimental well, 68 gallons originated by infiltration of the river water into the aquifer; the influence of the river on the aquifer was therefore 68%.

Bayonne Aquifer

The village of Saint-Cléophas is located on an elevated portion of the bedrock surface, near the eastern limit of the valley of the Bayonne river. An artesian aquifer was intersected by bore holes to the east of the village and seems to encircle it. It is possible that this aquifer extends over a large part of the valley.

The thickness of the permeable and saturated horizon ranges from 5 to 15 feet to the northeast of the village, in the vicinity of the experimental well. It is made up of sand and gravel beneath a bed of clay and lies on bedrock between 110 and 150 feet below surface.

In April of 1968, a 17-hour pumping test was carried out in the experimental well, at a rate of 40 g.p.m., and the piezometric levels were measured in neighbouring wells. The transmissibility and storage coefficients determined from the pumping data were, respectively, 3,300 g.p.d./ft. and 0.0018. Two negative barriers showed up during the tests; we were able to locate them at 125 and 200 feet from the pumping-observation well assemblage. A positive or recharge zone is apparently located at a distance of approximately 500 feet.

AQUIFERS FOR FUTURE STUDY

The work carried out in 1970 indicated the presence of a non-artesian aquifer (free water table) extending from the mouth of the Mastigouche river to the head of the Maskinongé river.

Section A (Fig. 16) shows the delta of the Mastigouche river as well as the sands of the overlying Lower Terraces.

At the elevation of bore hole 4926006, the medium to coarse-grained sand is saturated over the thickness of some 75 feet. This sand should provide an excellent aquifer. The sinking of an experimental well, surrounded by a network of piezometers, would be necessary to determine the transmissibility and storage coefficient of the aquifer as well as the quality of the water.

From a study of Section C (Fig. 19), it would appear that the north bank of the Maskinongé river is made up of sand and gravel in the vicinity of bore holes 4926001, 4922004 and 4922005. Here, the granular deposits lie directly on bedrock. This would also be a good location for an experimental well in order to measure the hydraulic constants of the aquifer and to determine the quality of the water.

CONCLUSIONS

Three of the five aquifers in the Lake Maskinongé area appear to offer excellent possibilities for providing an underground water supply to the small municipalities or industries of the area. Although less well known, the Mastigouche and Maskinongé aquifers also show favorable geologic conditions.

In 1971, only the Saint-Gabriel aquifer was being exploited, and at two-thirds of its capacity it was supplying about one million gallons per day. It serves as a source of water to the municipality of the same name, which also utilizes the water of Lake Maskinongé to meet its needs during the summer season, when demand is ten times above normal.

Over-all, the water circulating within the basin of Lake Maskinongé is influenced by the large drainage basin of the Matambin and Mastigouche rivers, covering an area of about 396 square miles. This watershed receives about 38 billion cubic feet of water of precipitation annualy, of which 12 billion infiltrates the surface to replenish the underground water reserves.

The influence of the hydrogeologic barriers confining the various aquifers, each with its own hydraulic characteristics, means that all of this water is not actually available at the desired time or place.

Nevertheless, with the information which we have gathered and interpreted to date within this region, we can confidently state that the aquifers are excellent and could, if used wisely, be determining factors in the economic development of the area.

APPENDIX - A

Wells and Bore Holes

NOTE - The table of wells and bore holes is divided into five columns, from left to right, as follows:

Identification Each point located on the map has been assigned a unique 9-digit identification number permitting reference to the hydrogeologic data bank (HDB) kept by the Quebec Department of Natural Resources. The first two digits represent the county, the next two the municipality and the following three the number of the well or bore hole, registered for the municipality in question. The eighth position allows a differentiation to be made between two points which could not be distinguished on the map at the 1:50,000 scale. Finally, the last digit indicates the type of information kept on file at the Department under the particular identification number.

UTM The bore holes were located to the nearest 100 metre, following the "Universal Transverse Mercator" (UTM) system. All of the holes were confined to the UTM 18 zone, within the limits of topographic maps 31 I/16 SW and 31 I/13 NW, at a scale of 1:50,000.

Altitude Except for bore holes 492202101 to 492202601 and 492600307 to 492600501, all of the altitudes (ground surface in relation to sea-level) were determined by reference to the 1:50,000 topographic map.

Geologic Section The geologic section was divided into two parts. To the left are the depths, in feet, measured from surface; to the right is a description of the materials intersected.

Hydrogeology This column was also divided into two parts. To the left are the hydrogeologic characteristics (water at the piezometric level, dynamic level and yield; to the right are the corresponding depths.

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
472100301	630.85 - 5132.85	520'	0'- 110': clay 110'- 112': gravel	P.L. - 17' N.D. - 24' Yield 8.3 g.p.m.
472100401	632.20 - 5131.75	500'	0'- 20': clay 20'- 102': gravelly sand 102'- 245': bedrock	P.L. - 40' D.L. - 60' Yield 3.1 g.p.m.
472100501	634.70 - 5131.20	550'	0'- 12': coarse sand 12'- 41': mud and clay 41'- 91': gravel, cobbles boulders A 91': bedrock	
491900111	628.30 - 5123.05	650'	0'- 8': top soil 8'- 400': bedrock (granite)	
491900501	625.40 - 5119.60	555'	0'- 20': gravel and cobbles 20'- 128': bedrock	P.L. - 14' D.L. - 20' Yield 6 g.p.m.
491900701	629.40 - 5118.13	550'	0'- 17': sand and boulders 17'- 190': bedrock	P.L. - 6' D.L. - 7' ? Yield 7 g.p.m.
491900901	625.55 - 5119.42	555'	0'- 6': sand 6'- 100': bedrock	P.L. - 3' D.L. - 12' Yield 5 g.p.m.
491901001	628.90 - 5119.60	600'	0'- 55': gravel and boulders 55'- 131': bedrock	P.L. - 22' D.L. - 35' Yield 3.5 g.p.m.
491901101	628.70 - 5122.80	625'	0'- 3': top soil 3'- 11': bedrock	Water at -11'
491901301	628.70 - 5121.60	655'	0'- 8': gravel 8'- 109': bedrock	P.L. - 40'
492200101	621.30 - 5131.30	535'	0'- 20': boulders 20'- 50': fine sand 50'- 86': gravel	P.L. - 20' D.L. - 45' Yield 3.3.g.p.m.
492200201	625.15 - 5128.30	600'	0'- 60': unconsolidated 60'- 71': gravel 71'- 140': bedrock (granite)	P.L. - Surface D.L. - 8' Yield 6 g.p.m.

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492200301	626.69 - 5131.57	510'	0'- 58': unconsolidated 58'- 225': bedrock	P.L. -18' D.L. -20' Yield 3 g.p.m.
492200401	626.73 - 5131.76	510'	0'- 25': unconsolidated 25'- 454': bedrock	P.L. -20' D.L. -33' Yield 1.9 g.p.m.
492200501	626.90 - 5131.85	510'	0'- 36': unconsolidated 36'- 395': bedrock	
492200601	627.05 - 5125.45	700'	0'- 18': gravel 18'- 90': bedrock (granite)	P.L. - 8' D.L. -15' Yield 5 g.p.m.
492200701	627.90 - 5124.15	650'	0'- 20': gravely sand 20'- 185': bedrock (granite)	P.L. -27' D.L. -28' Yield 5.4 g.p.m.
492200801	628.00 - 5130.70	510'	0'- 20': clay 20'- 53': gravel 53'- 290': bedrock (granite	P.L. -15' D.L. -25' Yield 3 g.p.m.
492200901	627.80 - 5132.03	520'	0'- 47': unconsolidated 20'- 53': gravel	P.L. -34' D.L. -44' Yield2.5 g.p.m.
492201001	629.43 - 5131.58	635'	0'- 90': gravel and boulders 90'- 419': bedrock (granite)	P.L. -57' D.L. -80'
492201101	623.38 - 5124.83	500'	0'- 265': sand 265'- 290': gravel 290'- 495': bedrock	P.L. -25' D.L. -100' Yield 5 g.p.m.
492201201	622.46 - 5123.70	500'	0'- 225': sand 225'- 240 ': gravel 240'- 430': bedrock	P.L. -50' D.L. -120' Yield 5 g.p.m.
492201301	623.30 - 5128.70	545'	0'- 3': filling 3'- 40': clay, gravelly sand 40'- 47': gravelly sand 47'- 300': boulder clay, silty sand 300'- 304': broken rock At 304': bedrock	P.L. surface

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492201401	625.70 - 5123.20	655'	0'- 3': top soil 3'- 81': bedrock	P.L. -5
492201501	623.80 - 5128.50	525'	0'- 1': top soil 1'- 30': clay 30'- 125': silty clay 125'- 160': sand, gravel boulders	P.L. surface D.L. -3' Yield 27 g.p.m.
492201601	623.00 - 5128.20	530'	0'- 1': top soil 1'- 4': gravelly sand 4'- 20': fine sand, boulder clay 20'- 35': sand 35'- 52': gravel, boulders beds of clay 52'- 80': sand and grave 80'- 110': sand, beds of clay 110'- 121': gravel, boulders, beds clay 121'- 141': clayey sand 141'- 163': boulders At 163': bedrock	P.L. surface D.L. ? Yield 327 g.p.m.
492201701	621.90 - 5131.60	500'	0'- 80': clay 80'- 82': bedrock	P.L. surface
492201801	630.20 - 5127.30	850'	0'- 37': gravelly clay 37'- 305': bedrock	P.L. -82'
492201901	630.20 - 5127.50	900'	0'- 27': gravel 27'- 300': bedrock	P.L. -40' D.L. -80' Yield 2.5 g.p.m.
492202001	633.60 - 5124.40	600'	0'- 15': top soil 15'- 247': bedrock	Water at -225'
492202101	621.60 - 5128.50	662'	0'- 18': sand, gravel 18'- 21': clay 21'- 29': sand, gravel 29'- 35': clay 35'- 50': sand, gravel 50'- 55': clay 55'- 61': sand, gravel 61'- 73': till At 73': bedrock	

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492202201	622.10 - 5126.70	527'	0'- 55': sand 55'- 105': clay 105'- 125': sand 125'- 165': clay 165'- 180': gravel 180'- 210': clay 210'- 220': gravel At 220': bedrock	
492202301	622.30 - 5125.70	519'	0'- 20': clay 20'- 67': clay, beds of sand 67'- 165': clay 165'- 175': boulder clay 175'- 340': clay 340'- 380': boulder clay At 380': bedrock	P.L. -10'
492202401	623.80 - 5126.20	594'	0'- 35': cobbles, gravel 35'- 110': sand, gravel 110'- 160': clay 160'- 185': boulder clay 185'- 195': clay 195'- 213': boulder clay 213'- 223': clay 223'- 255': boulder clay 255'- 275': clay 275'- 320': boulder clay 320'- 338': clay 338'- 345': boulder clay At 345': bedrock	P.L. -30'
492202501	623.20 - 5127.80	614'	0'- 20': medium to coarse sand 20'- 51': sand and gravel 51'- 58': cobbles 58'- 92': gravel with cobbles 92'- 135': clay 135'- 210': sandy clay 210'- 245': gravelly clay 245'- 262': boulder clay 262'- : bedrock	P.L. -3'

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492202601	622.90 - 5126.80	682'	0'- 8': gravel with cobbles 8'- 24': coarse sand and gravel 24'- 50'! gravel with cobbles 50'- 105': cobbles and boulders 105'- 178': clay, gravel, cobbles 178'- 305': clay	
492202701	623.50 - 5126.30	580'	0'- 188': clay 188'- 195': boulders 195'- 300': bedrock	P.L. -17' D.L. -175' Yield 6.6 g.p.m.
492202801	622.90 - 5128.70	560'	0'- 2': fine sand 2'- 40': dry clay 40'- 65': fine sand 65'- 178': clay, beds of sand 178'- 180': coarse sand At 180': bedrock	
492202901	623.30 - 5128.30	540'	0'- 12': fine sand 12'- 90': gray clay 90'- 190': gray clay, beds of sand 190'- 303': coarse sand and gravel At 303': bedrock	
492203001	625.30 - 5127.90	625'	0'- 2': fine sand 2'-- 46': clay 46'- 58': sand and gravel At 58': bedrock	
492203101	623.90 - 5128.60	480'	0'- 135': clay, beds of sand 135'- 175': gravel, boulders At 175': bedrock	
49600101	627.30 - 5132.30	520'	0'- 20': clay 20'- 117': gravelly sand 117'- 540': bedrock	P.L. -37' D.L. -45' Yield 5 g.p.m.

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492600301	627.40 - 5133.80	533'	0'- 25': medium sand 25'- 45': sand, beds of clay 45'- 115': clay 115'- 121': coarse sand, gravel At 121': bedrock	P.L. -4'
492600401	626.40 - 5133.90	548'	0'- 20': sand, gravel 20'- 30': gravelly clay 30'- 53': muddy clay 53'- 92': clay 92'- 101': gravel At 101': bedrock	P.L. -3'
492600501	624.80 - 5134.80	547'	0'- 13': gravel 13'- 33': sand, gravel clay 33'- 74': gravel 74'- 125': clay 125'- 131': gravel At 131': bedrock	P.L. -4'
492600601	623.40 - 5132.70	475'	0'- 75': medium to coarse sand 75' -286': clay, beds of gravels and boulders At 286': bedrock	
492600701	626.20 - 5135.80	530'	0'- 176': sand, boulders 176'- 285': bedrock	P.L. -18' D.L. -70' Yield 10 g.p.m.
492800301	620.40 - 5132.10	500'	0'- 5': fine sand 5'- 90': clay 90'- 95': coarse sand, gravel 95'- 118': clayey gravel At 118': bedrock	
492801701	621.03 - 5132.80	500'	0'- 7': sand 7'- 88': clay 88'- 94': gravel	P.L. -30' D.L. -60' Yield 3 g.p.m.

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
492801801	620.40 - 5131.95	510'	0'- 30': clay 30'- 97': sand 97'- 139': gravel, boulders 139'- 145': bedrock	P.L. -32' D.L. -95' Yield 2 g.p.m.
492801901	620.10 - 5131.90	510'	0'- 4': sand 4'- 40': clay 40'- 80': sand 80'- 81': gravel	P.L. -40' D.L. - ? Yield 3 g.p.m.
492802001	621.70 - 5133.40	500'	0'- 80': clay 80'- 135': gravel 135'- 300': bedrock	
492802101	616.80 - 5131.85	550'	0'- 2': clay 2'- 32': fine sand coarser at depth At 32': bedrock	
492802201	618.45 - 5131.80	525'	0'- 4': sand 4'- 37': clay 37'- 60': boulder clay beds of sand 60'- 65': gravel 65'- 84': gravel, boulders beds of clay At 84': bedrock	P.L. -20' D.L. -55' Yield 40 g.p.m.
581900501	621.85 - 5119.50	475'	0'- 100': clay, fine sand 100'- 121': bedrock	P.L. -10'
581900601	622.60 - 5120.10	540'	0'- 2': fine sand 2'- 15': clay 15'- 25': sand, gravel boulders At 25': bedrock	
581900801	623.40 - 5121.20	450'	0'- 113': clay 113'- 125': gravelly sand At 125': bedrock	P.L. flowing D.L. -50' Yield -40 g.p.m.
581900701	622.30 - 5120.80	500'	0'- 17': clay 17'- 45': sand, boulders	
582102701	622.65 - 5117.80	425'	0'- 20': clay 20'- 45': sand, gravel 45'- 91': bedrock	P.L. -15' D.L. -60' Yield 5 g.p.m.

LOG OF WELLS AND BORINGS

IDENTIFICATION	U.T.M. (x and y)	ALT.	GEOLOGICAL SECTION	HYDROGEOLOGY
582103001	623.45 - 5118.25	455'	0'- 6': gravel 6'- 180': bedrock	P.L. surface D.L. -20' Yield 3 g.p.m.
492600201	629.00 - 5135.70	490'	0'- 32': clay 32'- 40': gravel 40'- 275': bedrock	P.L. - 1' D.L. -70' Yield 5 g.p.m.
492600801	631.45 - 5137.75	625'	0'- 30': gravel, boulders	P.L. - 8' D.L. -25' Yield 3.3 g.p.m.
582105301	619.55 - 5119.50	485'	0'- 80': unconsolidated 80'- 230': sand 230'- 245': gravel	P.L. -60' D.L. -110' Yield 5 g.p.m.
492203501	624.20 - 5125.70	525'	0'- 188': clay 188'- 195': cobbles 195'- 300': bedrock	P.L. -17' D.L. -175' Yield 6.6 g.p.m.
492203601	628.10 - 5123.90	640'	0'- 35': unconsolidated, cobbles 35'- 115': bedrock	P.L. -18' D.L. -19' Yield 5 g.p.m.

APPENDIX - B

ELECTRIC LOGS

Figures 1 to 15

Clay

Sand

Gravel

Cobble

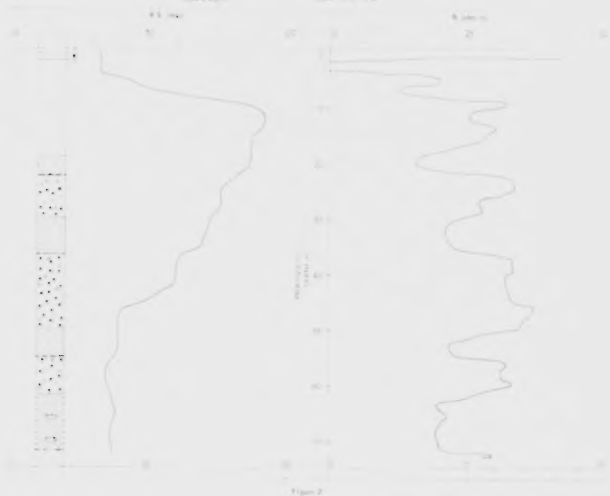
Boulder

Bedrock

Water level

IDENTIFICATION: 492202201
LOCALISATION: 18-622.10-5126.70
CARTE MAP: 31 I 6 SW
DATE: 10 11 70

IDENTIFICATION: 492202101
LOCALISATION: 18-621-60-5128.50
CARTE MAP: 31 I 6 SW
DATE: 06 11 70



IDENTIFICATION: 492202801
LOCALISATION: 18-622.90-5128.70
CARTE MAP: 31 I 6 SW
DATE: 28 06 65

DIAGRAMMES ELECTRIQUES TYPIQUES
TYPICAL E LOGS

IDENTIFICATION: 492202901
LOCALISATION: 18-623.30-5128.30
CARTE / MAP: 31 I / 6 SW
DATE: 27 / 05 / 65

Figure 4

IDENTIFICATION: 492203001
LOCALISATION: 18-625.30-5127.90
CARTE / MAP: 31 I 6 SW
DATE: 02 / 06 65

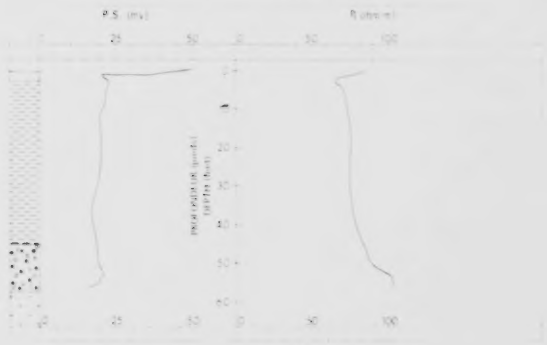


Figure 5

IDENTIFICATION: 492203101
LOCALISATION: 18-623.90-5128.60
CARTE / MAP: 31 I / 6 SW
DATE: 31 / 06 / 65

Figure 6

DIAGRAMMES ÉLECTRIQUES TYPIQUES
TYPICAL E-LOGS

IDENTIFICATION: 492600601
LOCALISATION: 18-623.40-5132.70
CARTE / MAP: 31 I/6 SW
DATE: 01/06/65

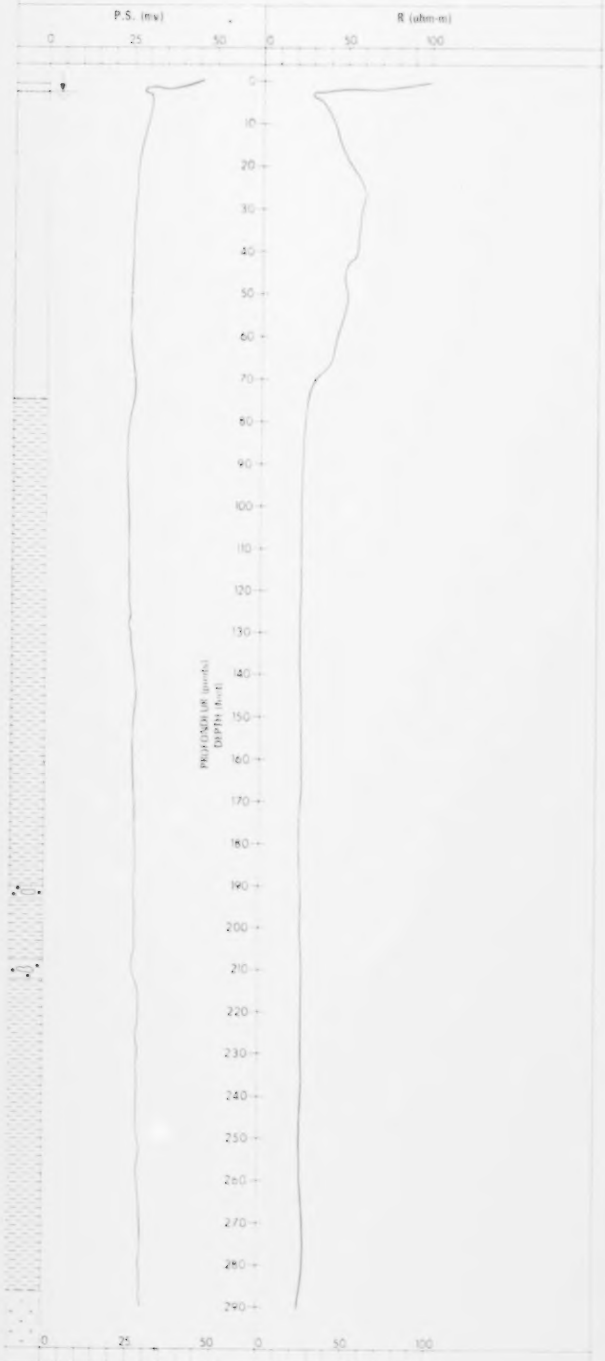


Figure 7

IDENTIFICATION: 492202301
LOCALISATION: 18-622.30-5125.70
CARTE / MAP: 31 I/6 SW
DATE: 11/11/70

Figure 8

DIAGRAMMES ELECTRIQUES TYPIQUES
TYPICAL E-LOGS

IDENTIFICATION: 492202401
LOCALISATION: 18-623.80-5126.20
CARTE / MAP: 31 I/6 SW
DATE: 12/11/70

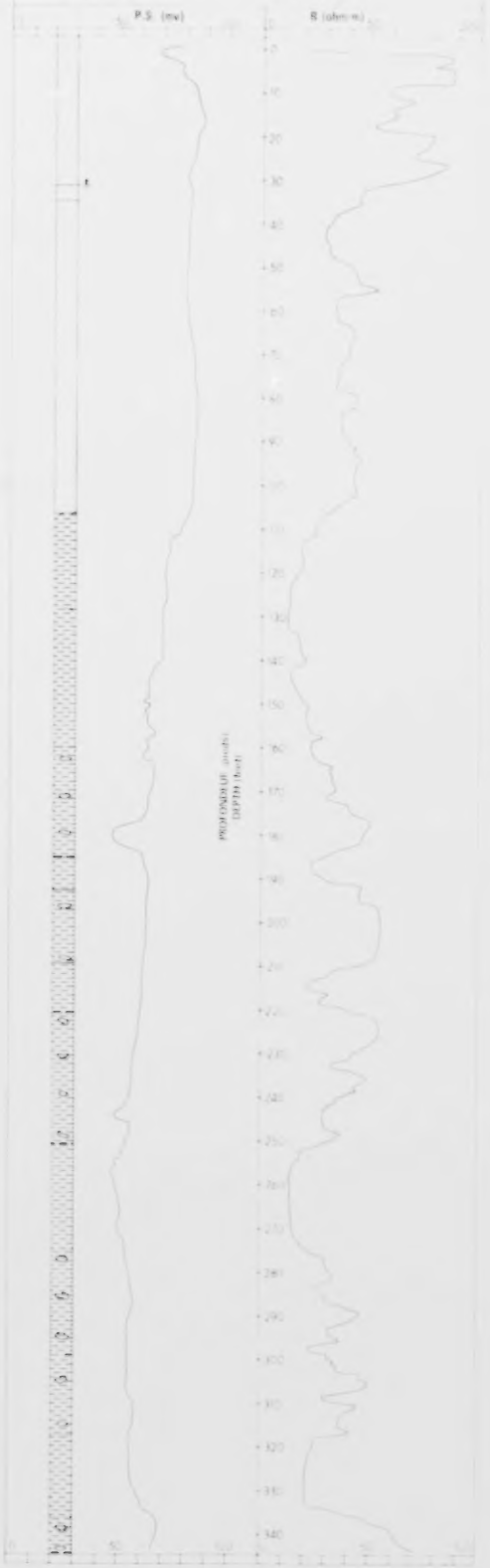


Figure 9

IDENTIFICATION: 492202501
LOCALISATION: 18-623.20-5127.80
CARTE / MAP 31 I/6 SW
DATE: 14/11/70

Figure 10

DIAGRAMMES ELECTRIQUES TYPIQUES TYPICAL E-LOGS

IDENTIFICATION: 492600301
LOCALISATION: 18-627.40-5133.80
CARTE / MAP: 31 I/6 SW
DATE: 17/11/70

Figure 11

H-681

DIAGRAMMES ÉLECTRIQUES TYPIQUES TYPICAL E-LOGS

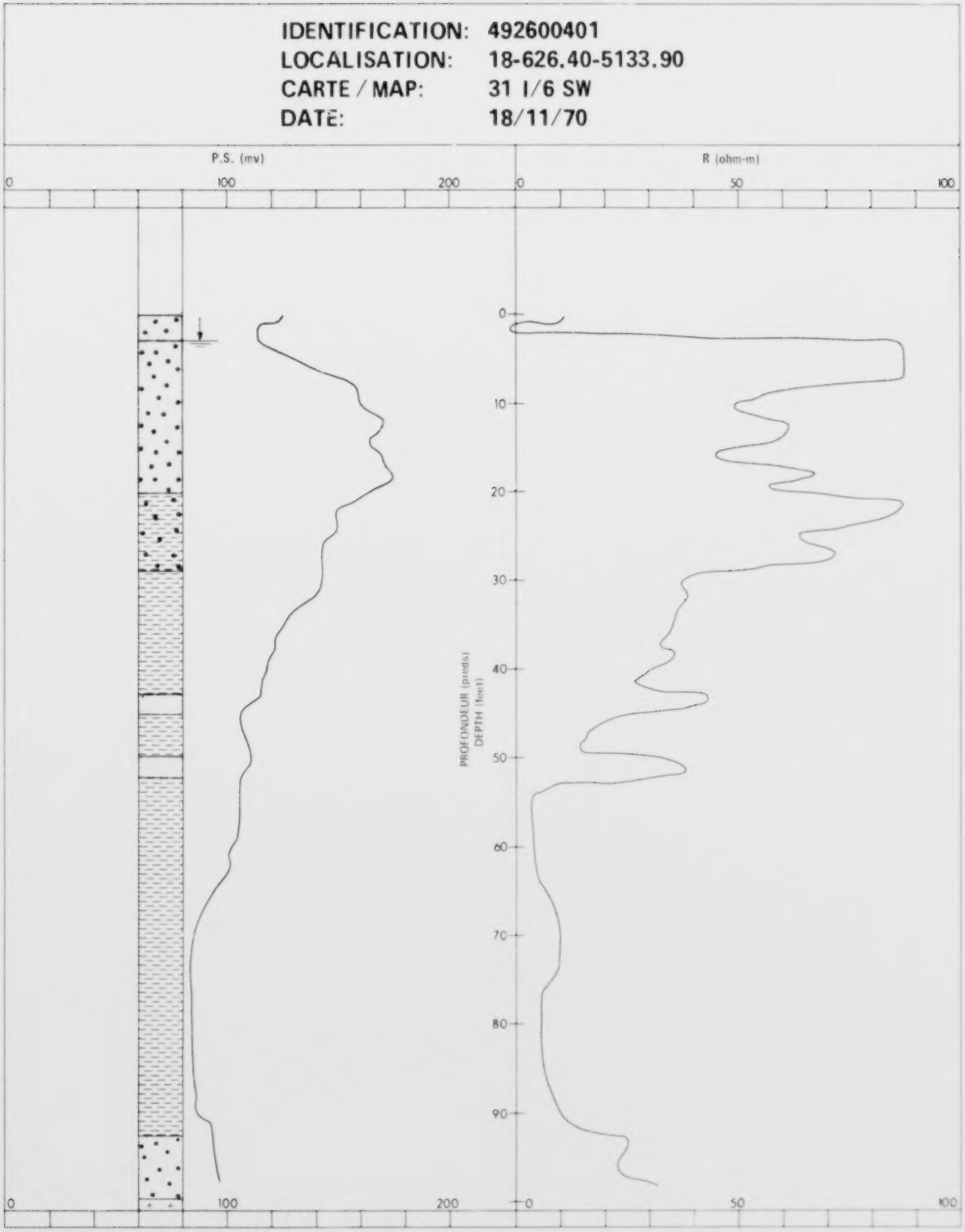


Figure 12

DIAGRAMMES ÉLECTRIQUES TYPIQUES TYPICAL E-LOG

IDENTIFICATION: 492600501
LOCALISATION: 18-624.80-5134.80
CARTE / MAP: 31 I/6 SW
DATE: 19/11/70

Figure 13

IDENTIFICATION: 472100501
LOCALISATION: 18-634.70-5131.20
CARTE / MAP: 31 I/6 SW
DATE: 21/11/70

Figure 15

IDENTIFICATION: 492202601
LOCALISATION: 18-622.90-5126.80
CARTE / MAP 31 I/6 SW
DATE: 20/11/70

Figure 14

DIAGRAMMES ELECTRIQUES TYPIQUES TYPICAL E-LOGS

APPENDIX - C

GEOLOGICAL SECTIONS

A to F

LÉGENDE DES COUPES GÉOLOGIQUES

GEOLOGICAL SECTIONS LEGEND

7 — Sédiments de Basses-Terrasses
Sediments of low terraces

6 — 6a: Sédiments de Hautes-Terrasses
6: Sédiments deltaïques
6a: Sediments of high terraces
6: Deltaic sediments

5 — Sédiments d'eau profonde de la mer Champlain
(inclus sédiments de plages du début et de la fin de la transgression marine)
Deep-sea sediments of the Champlain Sea
(including beach sediments at the end phases of marine invasion)

4 — Dépôts de contact glaciaire et d'épandage
Ice-contact deposits and outwash sediments

3 — 3a: Sédiments deltaïques glacio-marins
3: Dépôts glaciaires du système morainique de Saint-Narcisse
3a: Deltaic sediments
3: Glacial drift of the Saint-Narcisse morainic system

2 — Moraine de fond et d'ablation
(inclus dépôts fluvioglaciaires lors d'avancés et de retraits de la mer
Ablation and ground moraines over the bedrock
(Glacio-fluvial sediments included)

1 — Roche en place
Bedrock

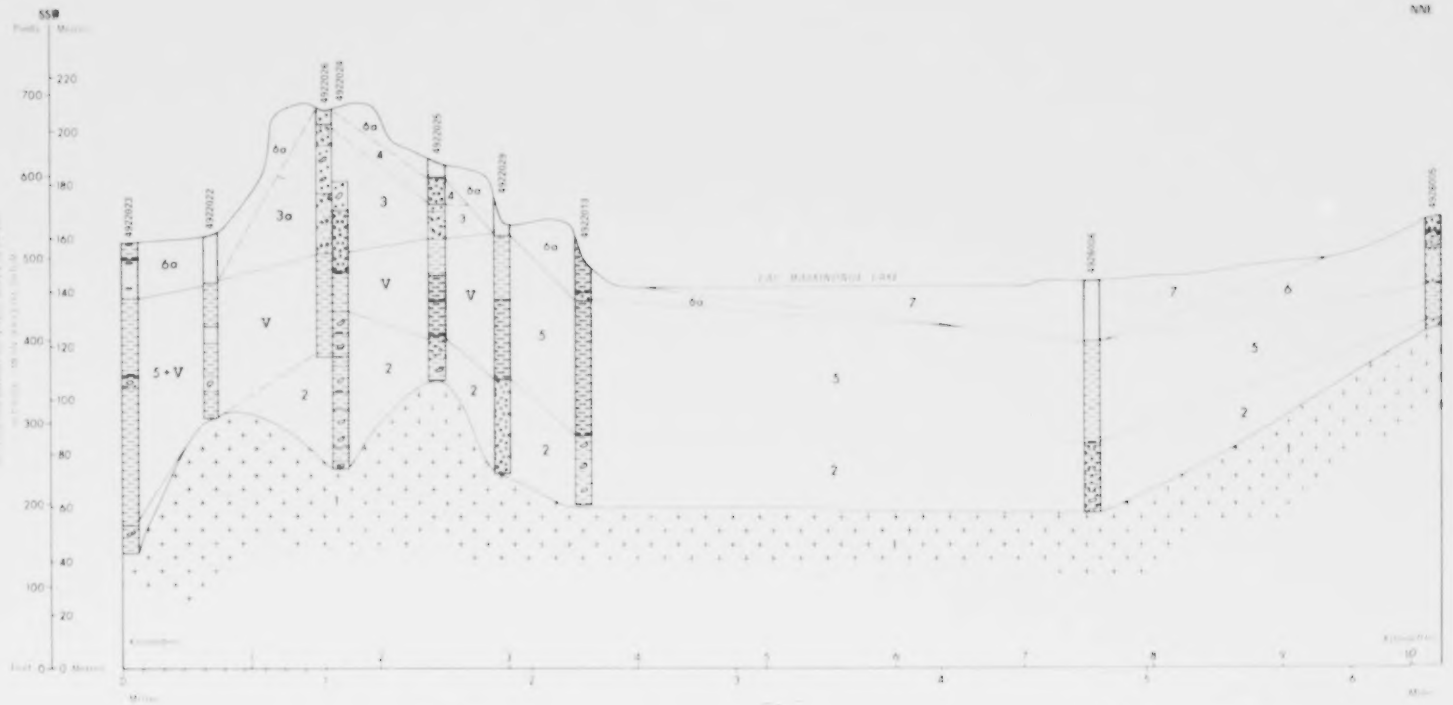
V — Sédiments d'eau profonde de pré-récurrence glaciaire recouverts par la moraine de Saint-Narcisse
Deep-sea sediments covered by the Saint-Narcisse morainic system

Argile *Clay* — Sable *Sand* — Gravier *Gravel* — Cailloux *Cobble* — Blocs *Boulder* — Roche en place *Bedrock*

Contact géologique: (a) approximatif, (b) présumé
Geological boundary: (a) approximate, (b) assumed

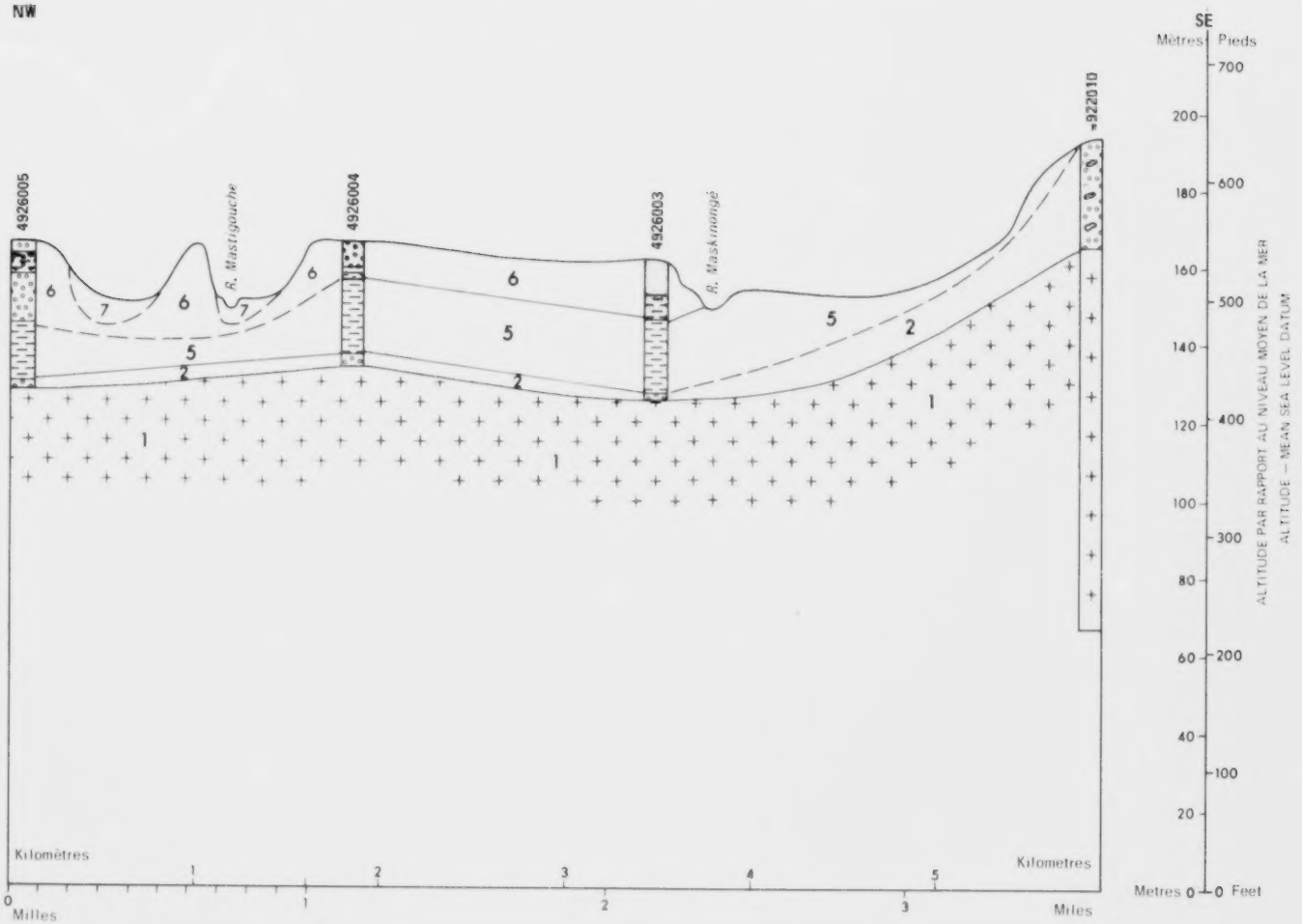
? — Matériau ou profondeur au roc inconnu
Unknown material or depth to bedrock

Puits ou forage 4928020
Well or boring 4928020



COUPE A

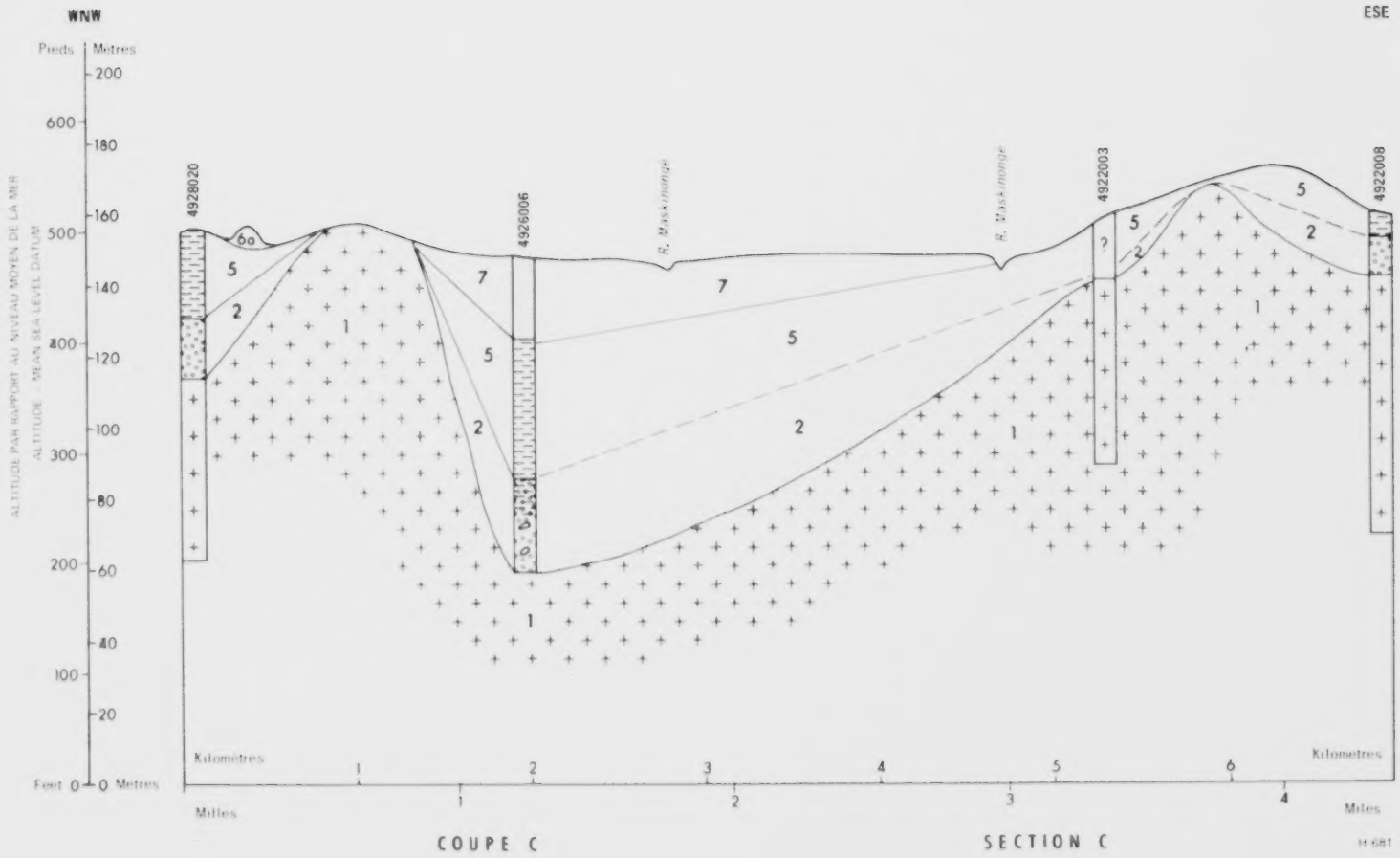
SECTION A

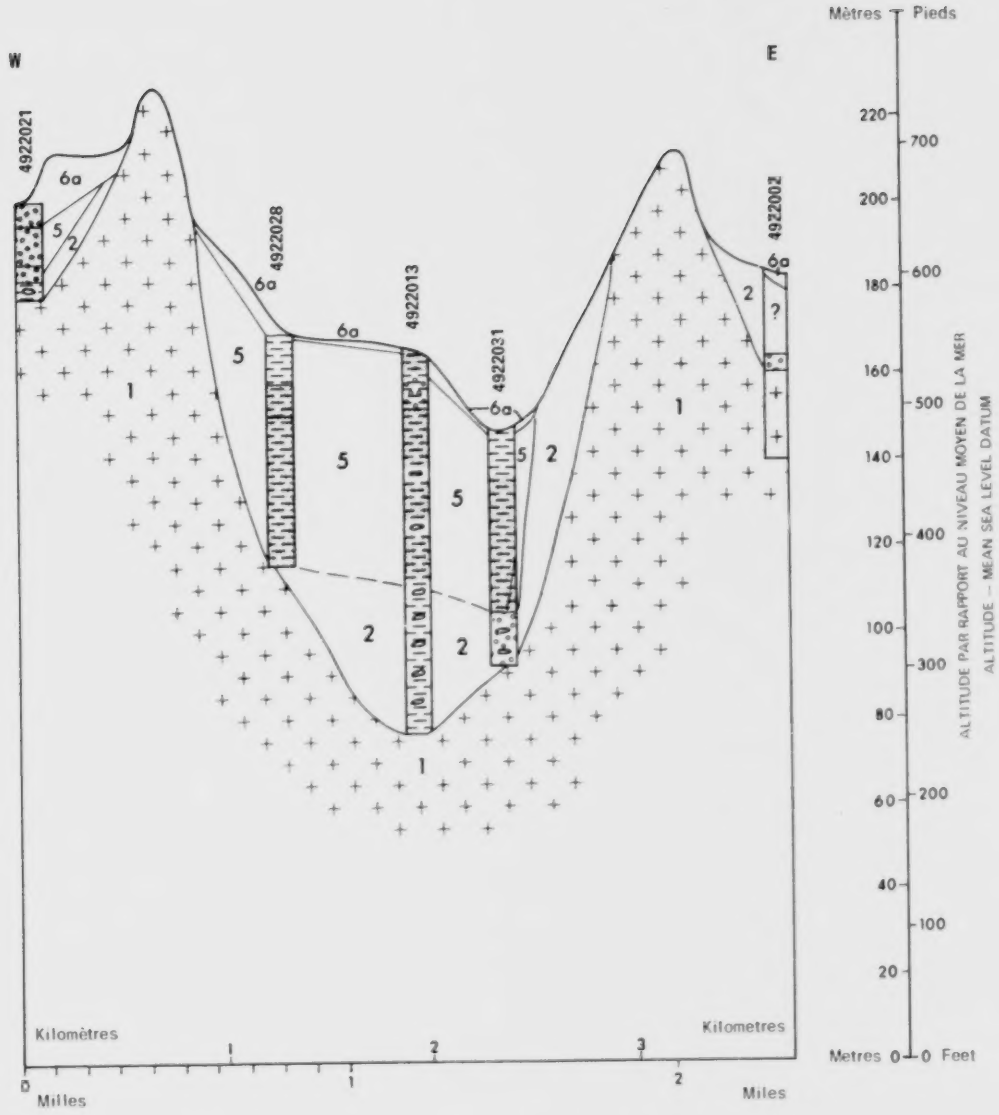


COUPE B

SECTION B

H-681

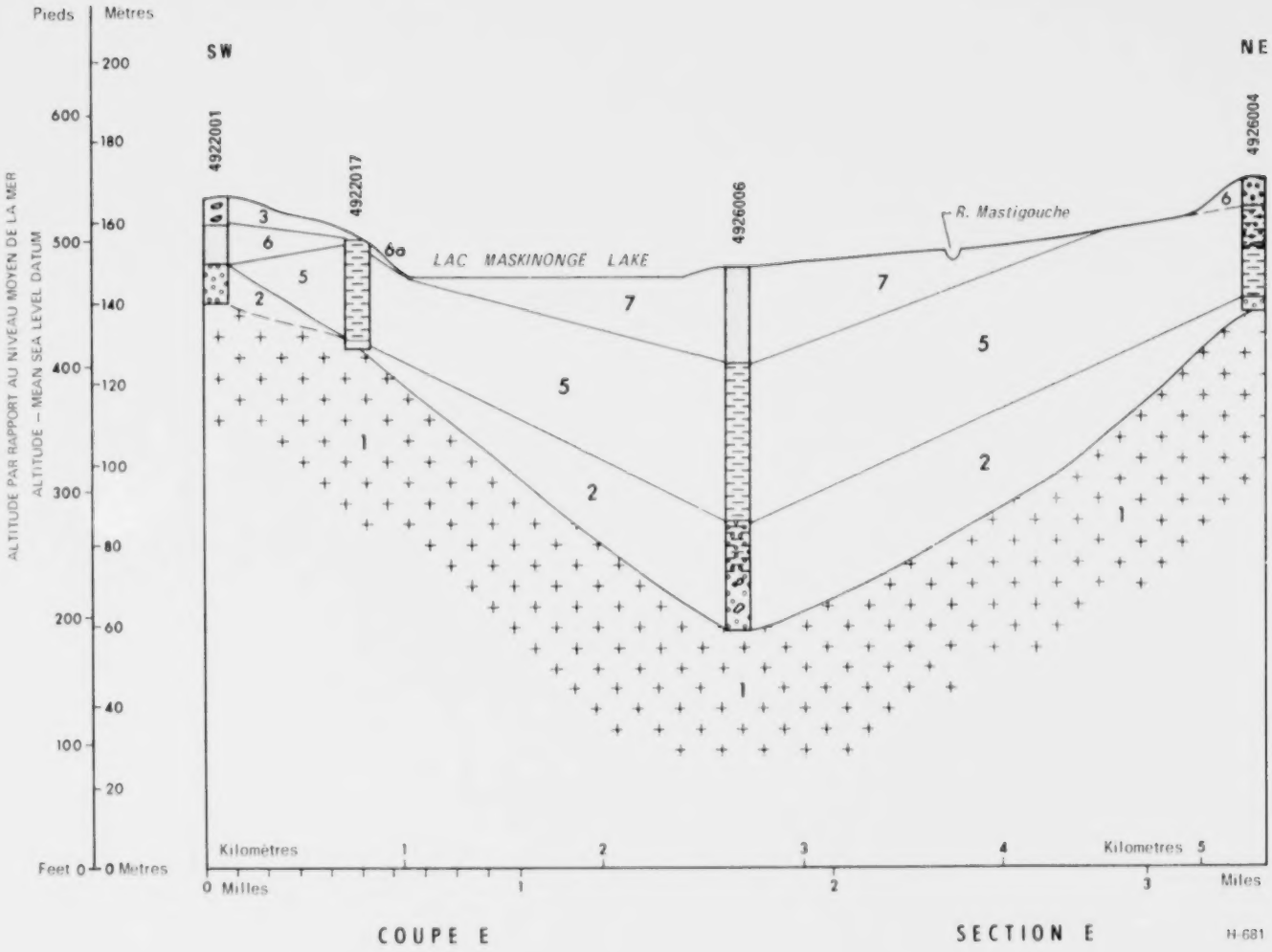

WNW
ESE
Pieds
Mètres
ALTITUDE PAR RAPPORT AU NIVEAU MOYEN DE LA MER
ALTITUDE - MEAN SEA LEVEL DATUM
600
500
400
300
200
100
Feet 0
200
180
160
140
120
100
80
60
40
20
0 Mètres
4928020
4926006
4922003
4922008
R. Massinonge
R. Massinonge
6a
6b
5
2
1
7
5
2
7
5
2
?
5
2
5
2
1
1
Kilomètres
Kilometres
1
2
3
4
5
6
Miles
1
2
3
4
Miles
COUPE C
SECTION C
H 681

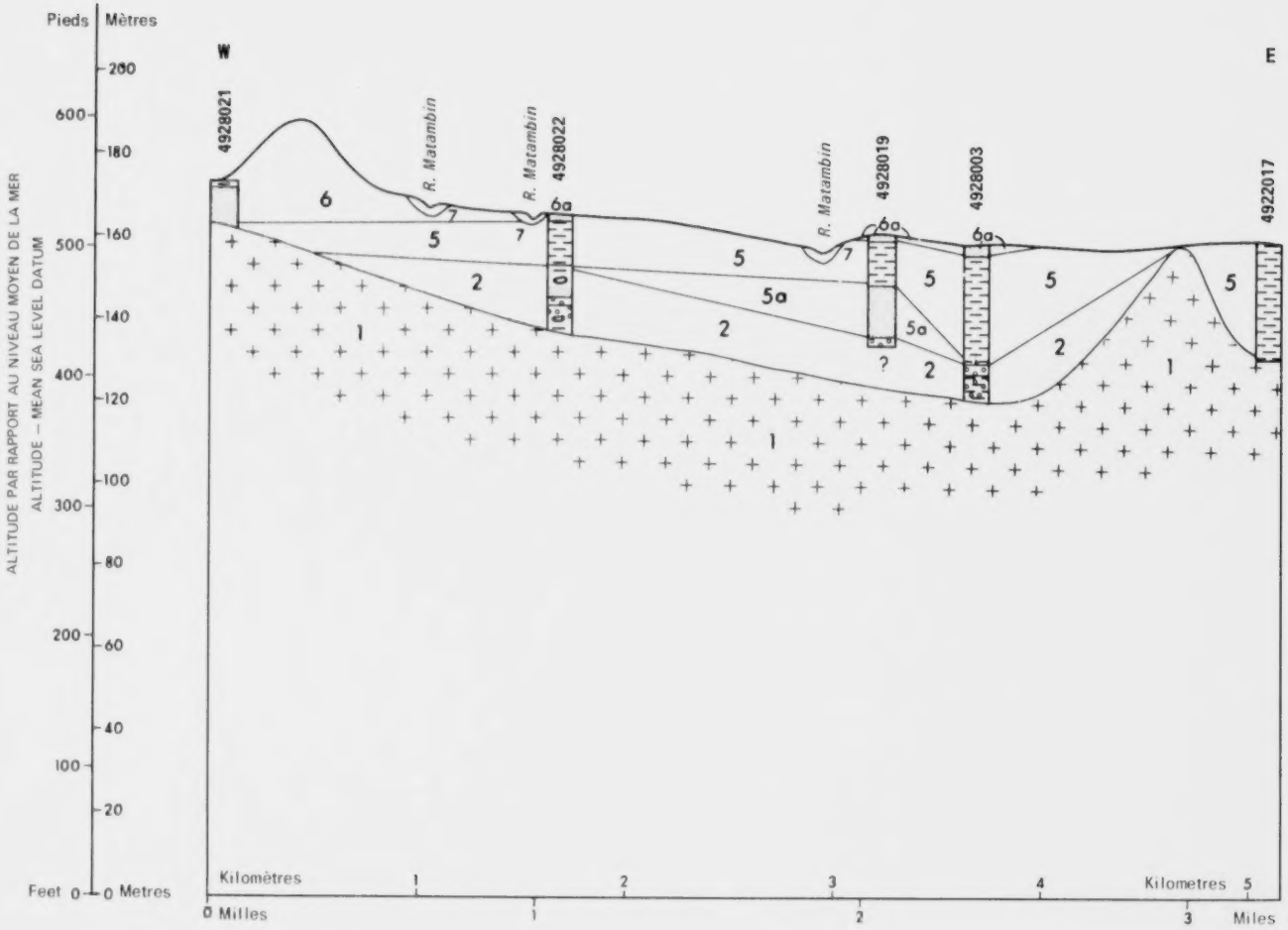


COUPE D

SECTION D

H-681


Pieds
Mètres
ALTITUDE PAR RAPPORT AU NIVEAU MOYEN DE LA MER
ALTITUDE – MEAN SEA LEVEL DATUM
Feet 0
0 Metres
SW
NE
4922001
4922017
4926006
4926004
LAC MASKINONGE LAKE
R. Mastigouche
Kilomètres
Kilometres
0 Milles
Miles
COUPE E
SECTION E
N-681



COUPE F

SECTION F

H-681

APPENDIX D

CHEMICAL ANALYSIS

Figures 22 to 33

Table of analysis

CHEMICAL ANALYSIS

CONSTITUANTS IN MG/L (EXCEPT COLOR AND pH)

SAMPLE NO.	COLOR (units)	TOTAL HARDNESS	ALKALINITY	CALCIUM	MAGNESIUM	IRON	CARBONATES	BI-CARBONATES	CHLORIDES	SULPHATES	NITRATES	FLUOR	DISSOLVED SOLIDS	pH	MANGANESE	SODIUM	POTASSIUM
1	5	217	119	70	18	0.2	Nil	145	138	40	0.5	Nil	472	7.7	0.4	53	10
2	10	73	51	22	10	0.5	Nil	62	14	19	---	Nil	134	7.7	0.3	6.9	1.4
3	5	77	79	22	10	0.2	Nil	97	14	20	---	Nil	152	7.8	0.3	16	3.0
4	0	68	48	23	11	.04	Nil	58	14	24	0.8	Nil	132	7.7	Nil	5.4	Nil
5	15	16	16	7.1	7.9	2.0	Nil	19	11	3.7	0.8	Nil	62	6.4	.05	2.7	Nil
6	0	72	87	25	8.2	0.7	Nil	106	11	3.3	4.0	0.2	170	7.7	0.2	15	2.2
7	23	64	54	36	28	1.0	---	54	3.5	17	Nil	Nil	---	7.8	Nil	---	---
8	0	29	140	13	8	0.2	Nil	171	78	21	4.4	4.0	330	7.9	---	104	10
9	5	137	152	25	18	Nil	Nil	161	94	59	2.0	15	377	8.3	Nil	111	9.0
10	0	52	78	17	8.4	.02	Nil	95	11	1.2	0.3	0.2	151	7.6	.05	21	5.1
11	0	61	77	19	10	0.2	Nil	94	11	2.9	---	0.1	130	7.5	.05	14	2.4
12	3	126	66	Nil	31	0.2	Nil	81	19	54	44	Nil	250	6.5	.08	24	2.6
13	33	43	78	14	2.0	0.2	Nil	45	0.5	14	1.3	0.3	454	6.4	.23	4.8	1.0

EXPLANATORY NOTES

pH and pH*: The pH is the negative exponent of the logarithm of the concentration of the H ion.

The pH* of equilibrium is found on the vertical, half-way between the Ca and HCO_3 ions on the different graphs, at the intersection with the straight line joining the two ions. This value is corrected for ionic force and temperature, and then converted into the usual form by a moving graphic pH scale. Mathematically, $pH = \sqrt{rCa + rHCO_3}$.

μ : Ionic force, as expressed by the equation:

$$\mu = 1/2 \quad (2rCa + 2rMg + rNa + 2rSO_4 + rHCO_3 + rCO_3) \quad x \quad 10^{-3}$$

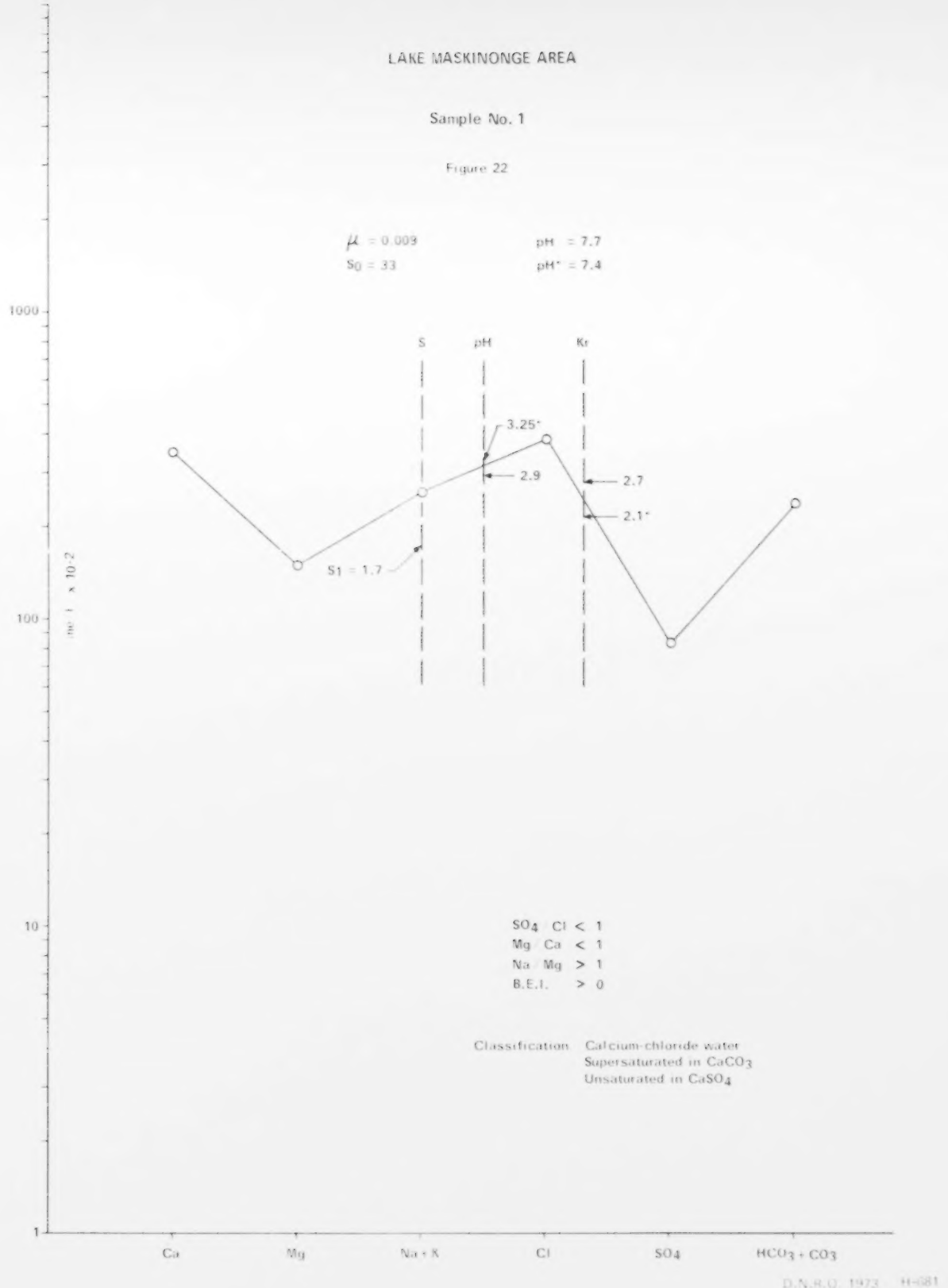
S and So : These are the saturation points of $CaSO_4$, as determined graphically on the vertical mid-way between Ca and SO_4 at the point of intersection with the straight line joining the two ions. A solubility scale gives the So value for different concentration of NaCl at 20^oC.

Kr and Kr*: These values represent the quantity of $CaCO_3$ that can be dissolved by water. They are located on the vertical, two-thirds of the way between Ca and HCO_3. Kr* indicates the value has been corrected and related to a uniform ionic force for all analyses.

LAKE MASKINONGE AREA

Sample No. 1

Figure 22

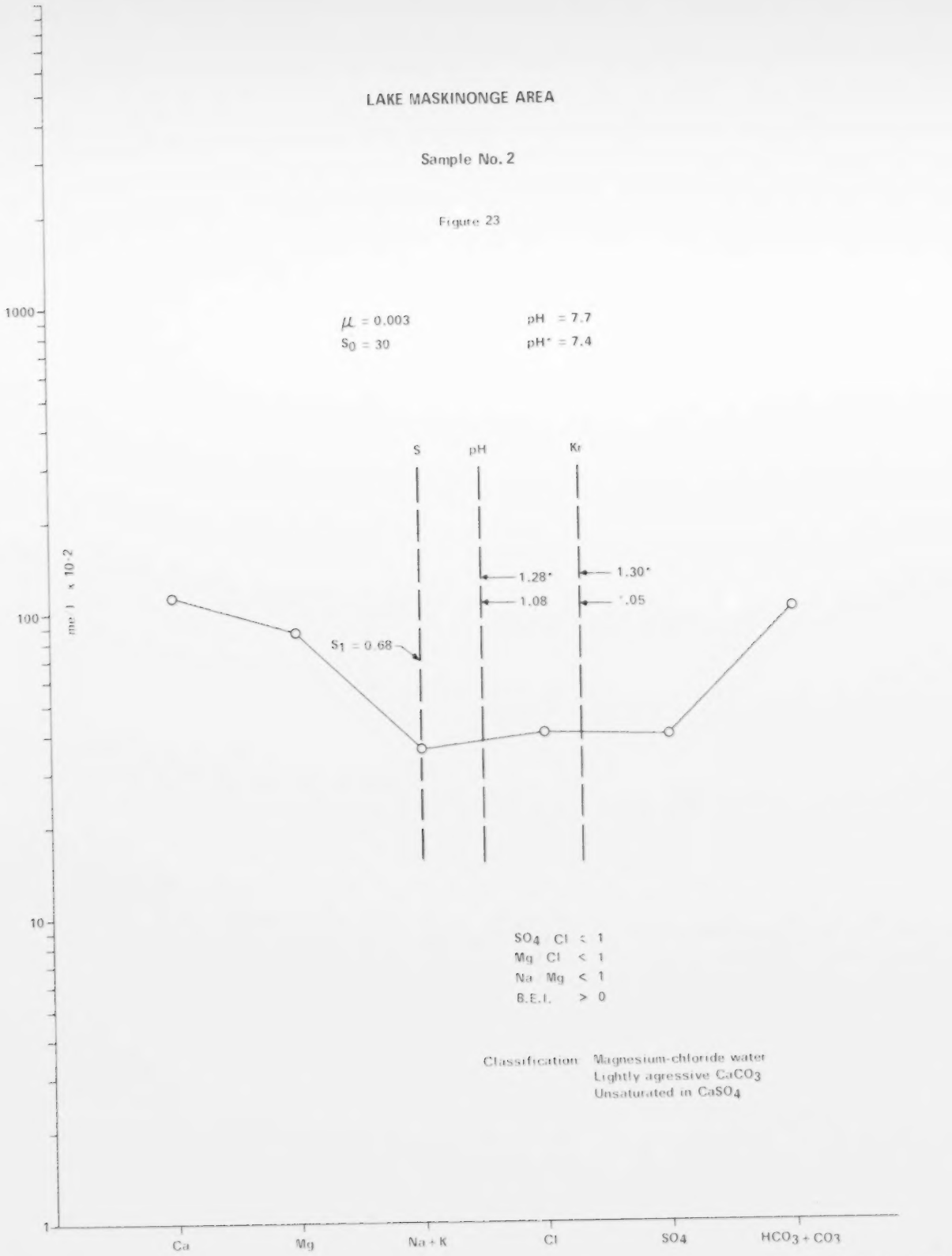


D.N.R.Q. 1973 H-681

LAKE MASKINONGE AREA

Sample No. 2

Figure 23

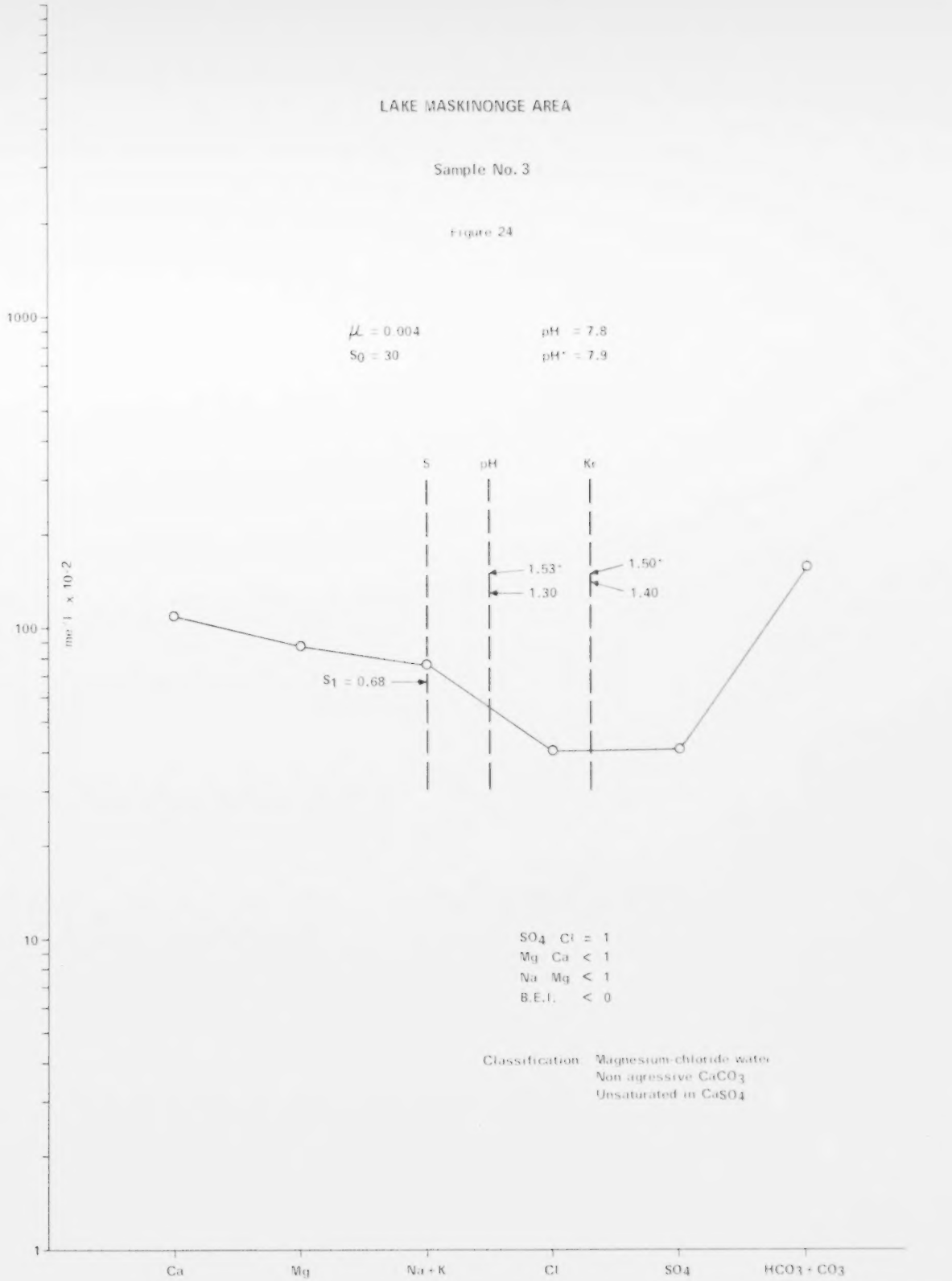


D.N.R.Q. 1973 H-681

LAKE MASKINONGE AREA

Sample No. 3

Figure 24

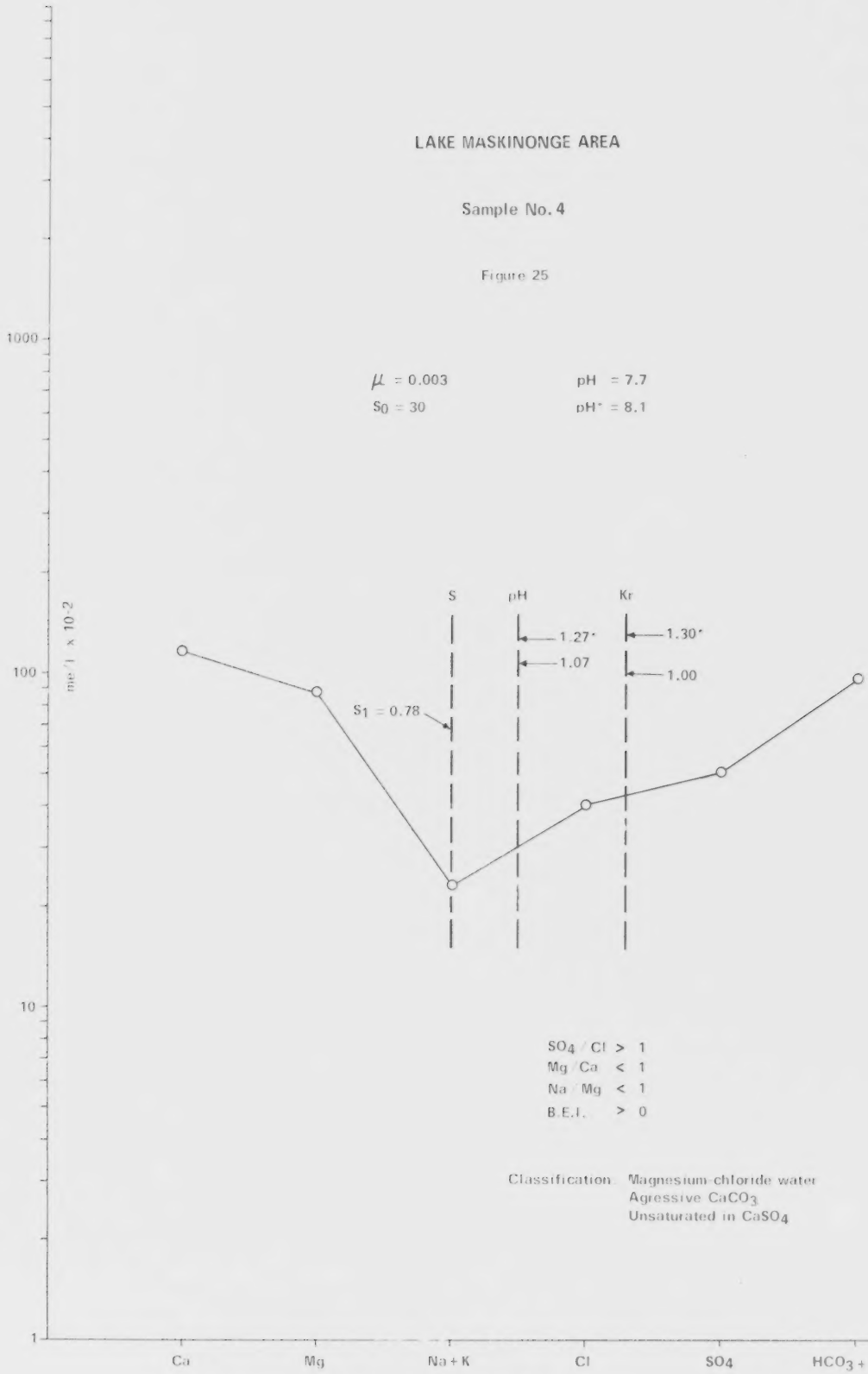


O.N.R.O. 1973 H-681

LAKE MASKINONGE AREA

Sample No. 4

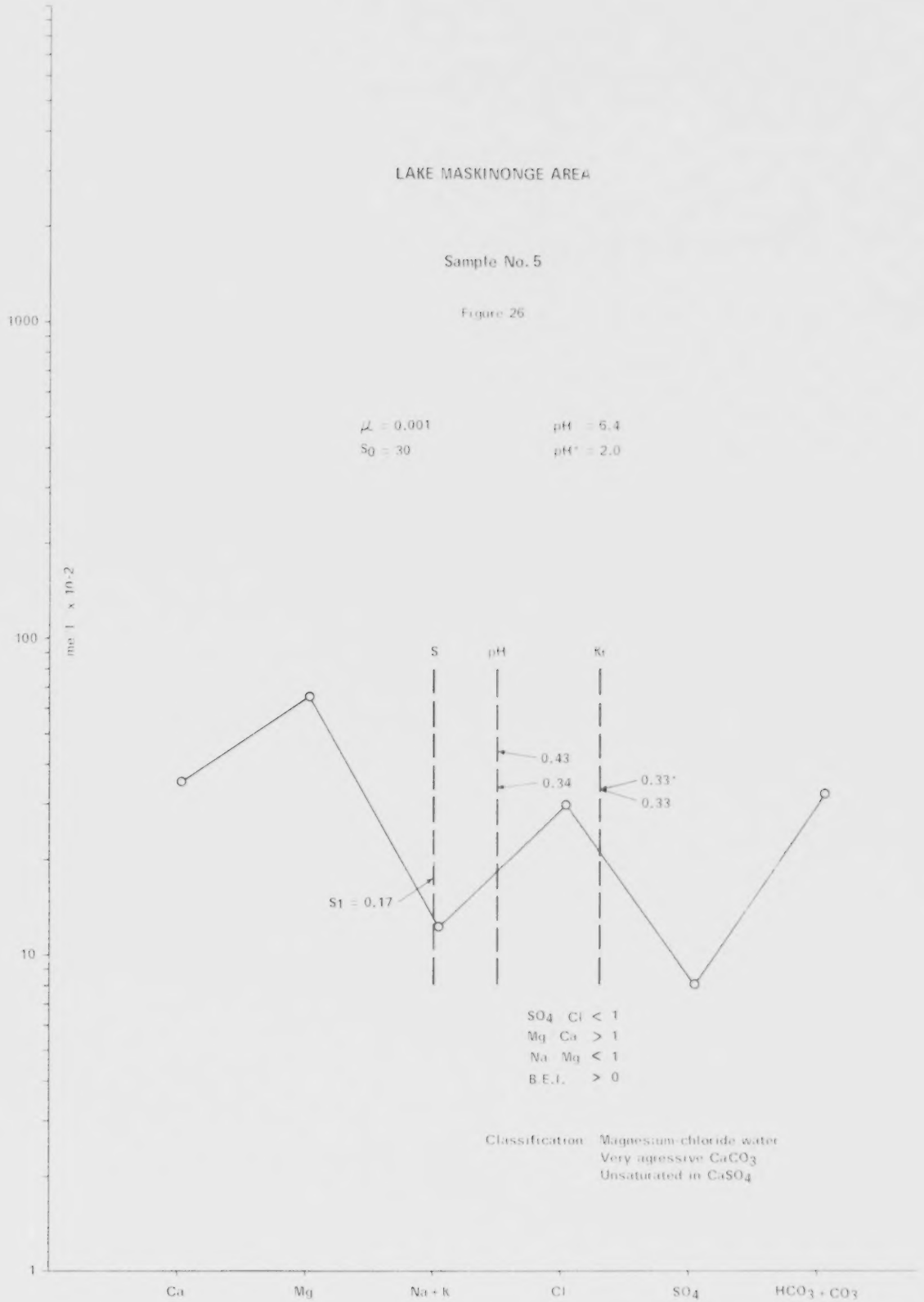
Figure 25



LAKE MASKINONGE AREA

Sample No. 5

Figure 26



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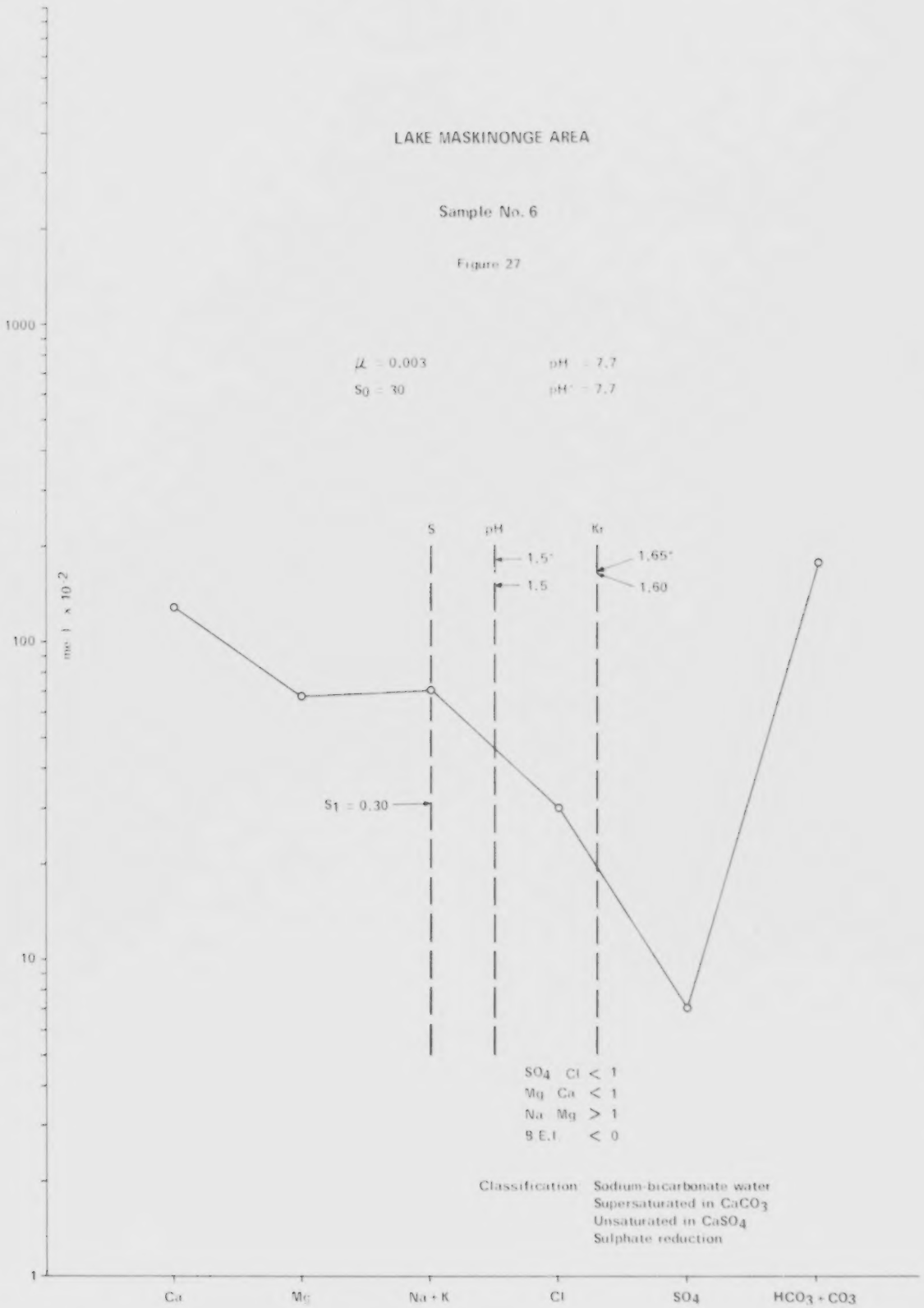
LAKE MASKINONGE AREA

Sample No. 6

Figure 27



D.N.R.C. 1973 H-681

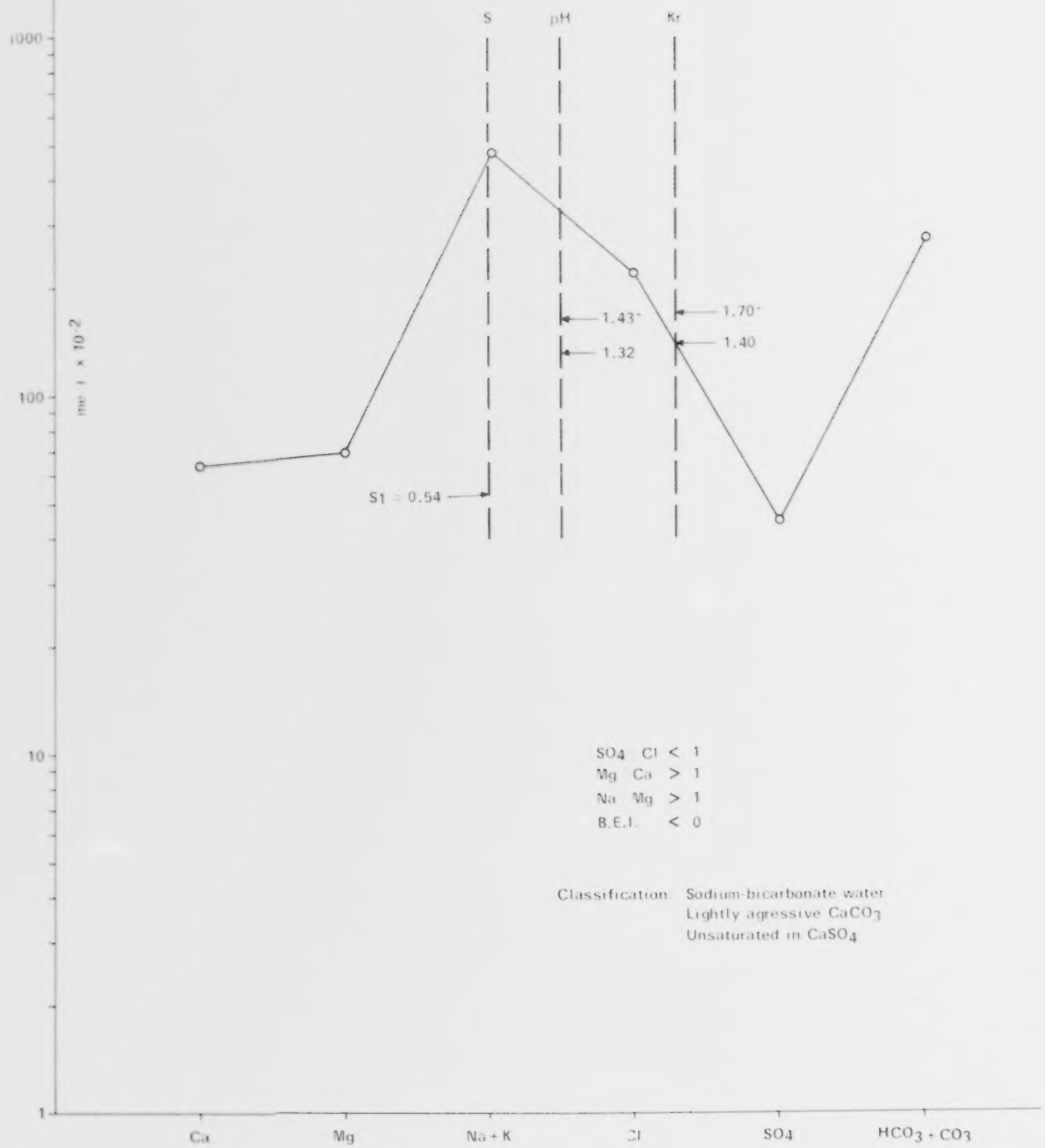
LAKE MASKINONGE AREA

Sample No. 8

Figure 28

μ = 0.007 pH = 7.9

S_0 = 32 pH' = 7.9



SO_4 Cl < 1

Mg Ca > 1

Na Mg > 1

B.E.I. < 0

Classification: Sodium-bicarbonate water
Lightly agressive $CaCO_3$
Unsaturated in $CaSO_4$

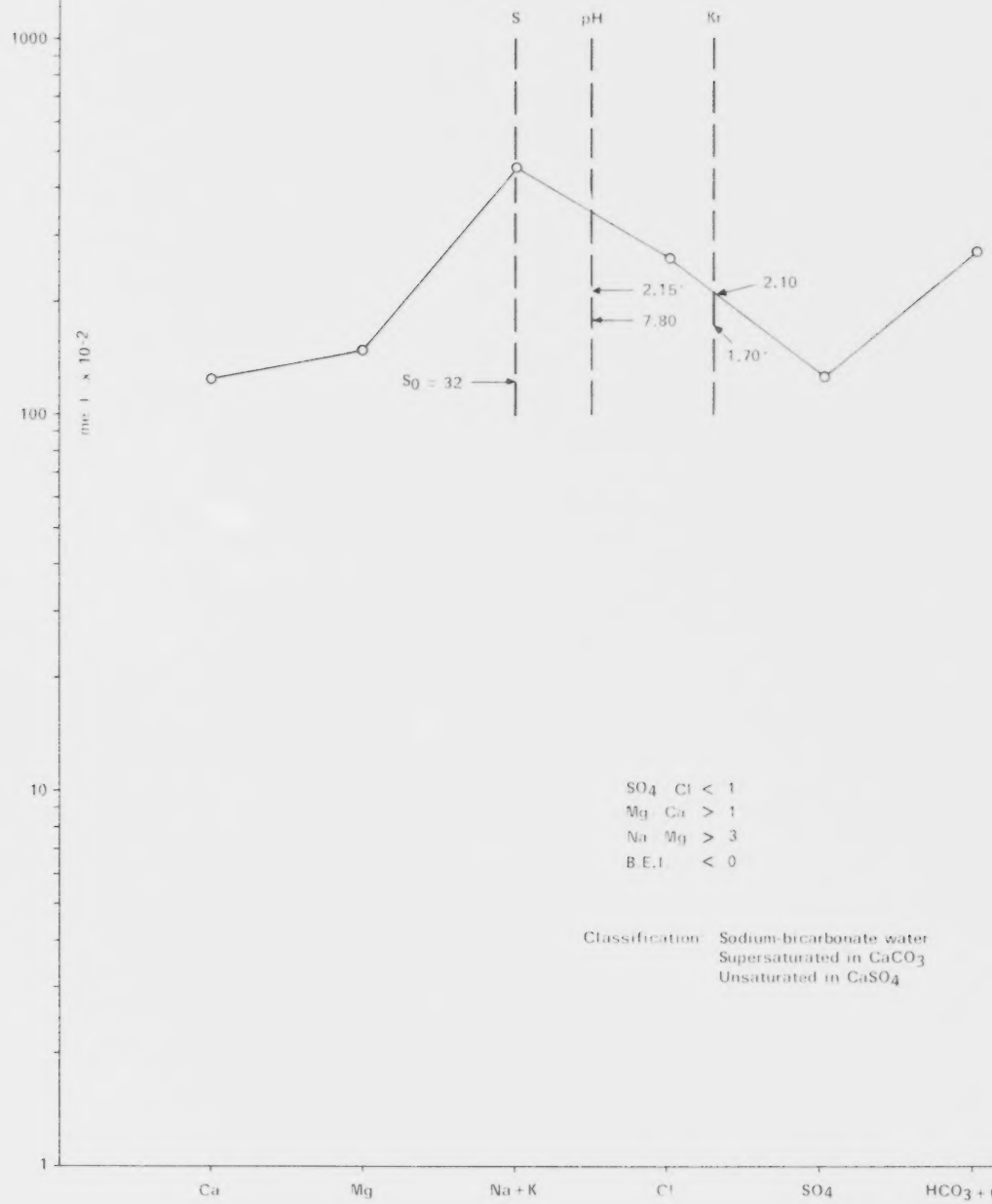
LAKE MASKINONGE AREA

Sample No. 9

Figure 29

μ = 0.009 pH = 8.3

S_0 = 32 pH' = 7.75



SO_4 Cl < 1

Mg Ca > 1

Na Mg > 3

B.E.I < 0

Classification: Sodium-bicarbonate water
Supersaturated in $CaCO_3$
Unsaturated in $CaSO_4$

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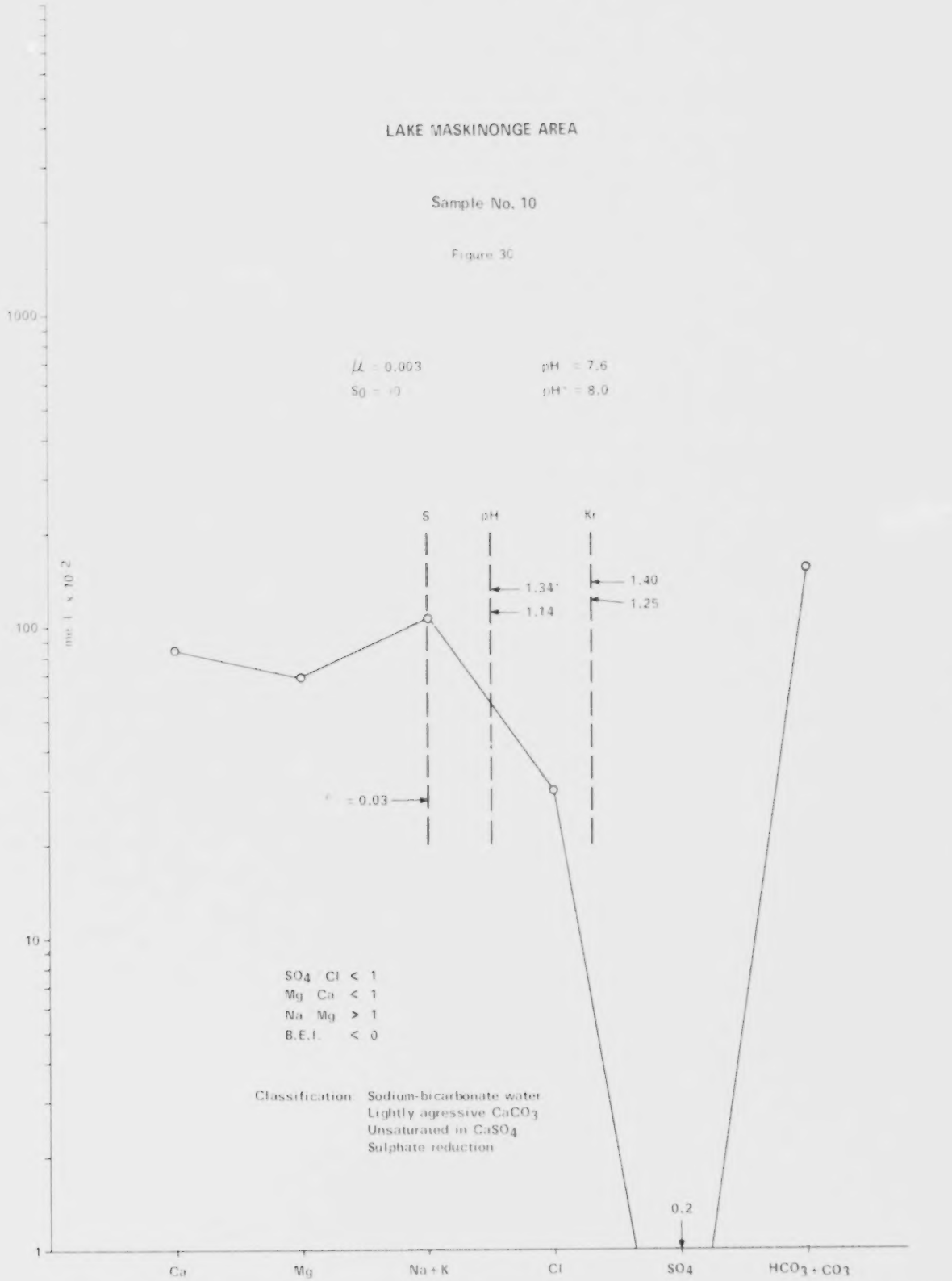
LAKE MASKINONGE AREA

Sample No. 10

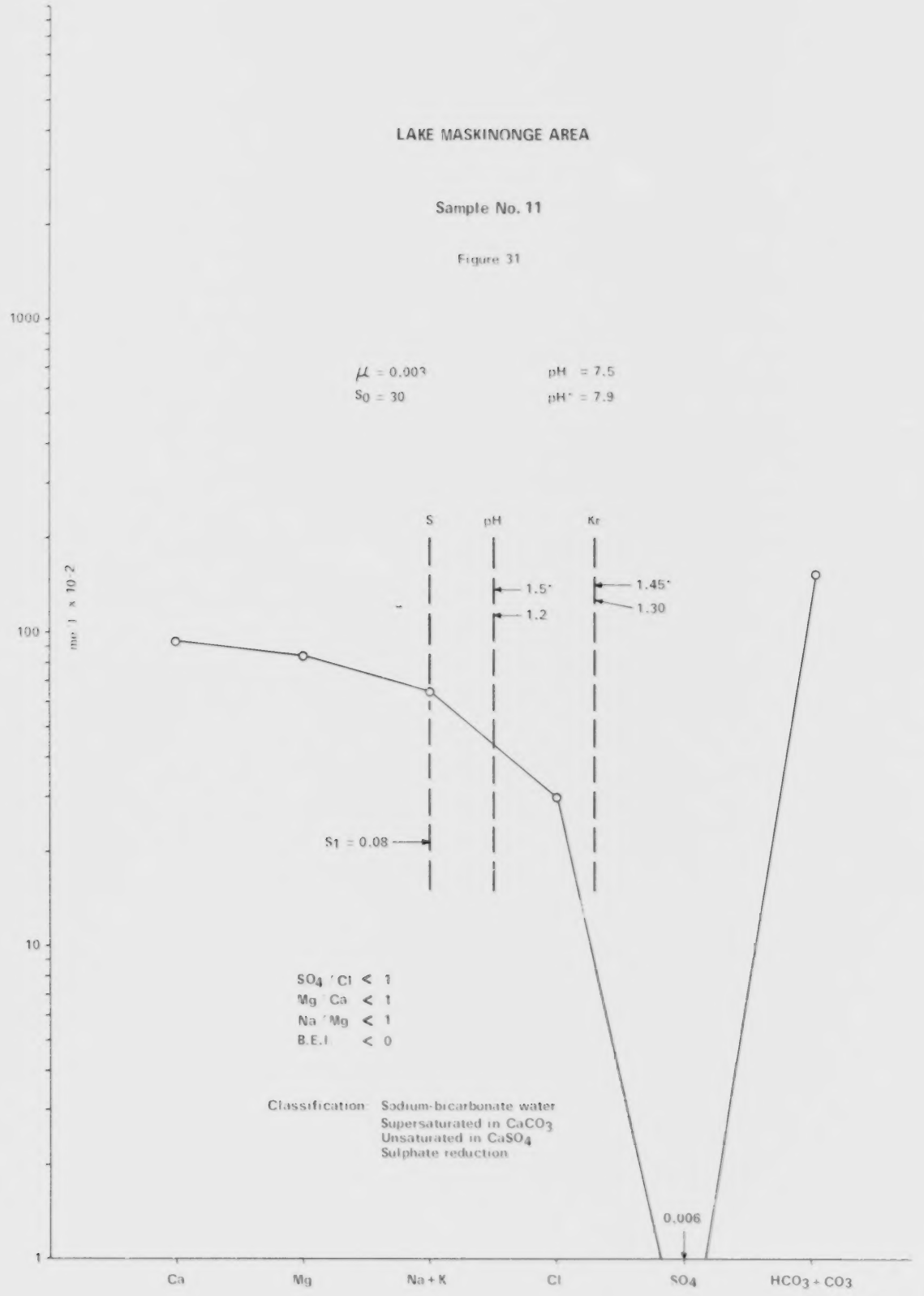
Figure 30



LAKE MASKINONGE AREA

Sample No. 11

Figure 31



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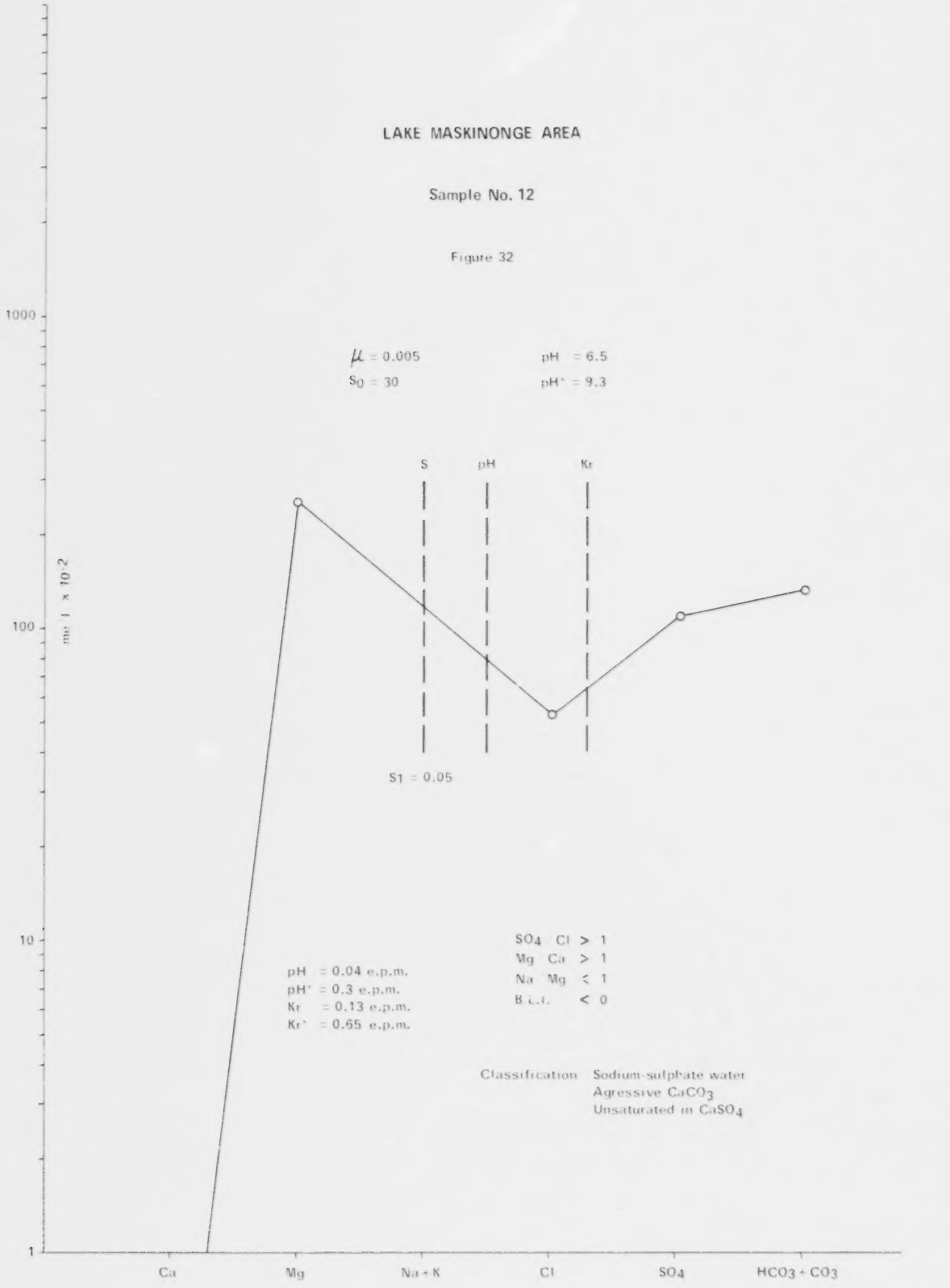
LAKE MASKINONGE AREA

Sample No. 12

Figure 32



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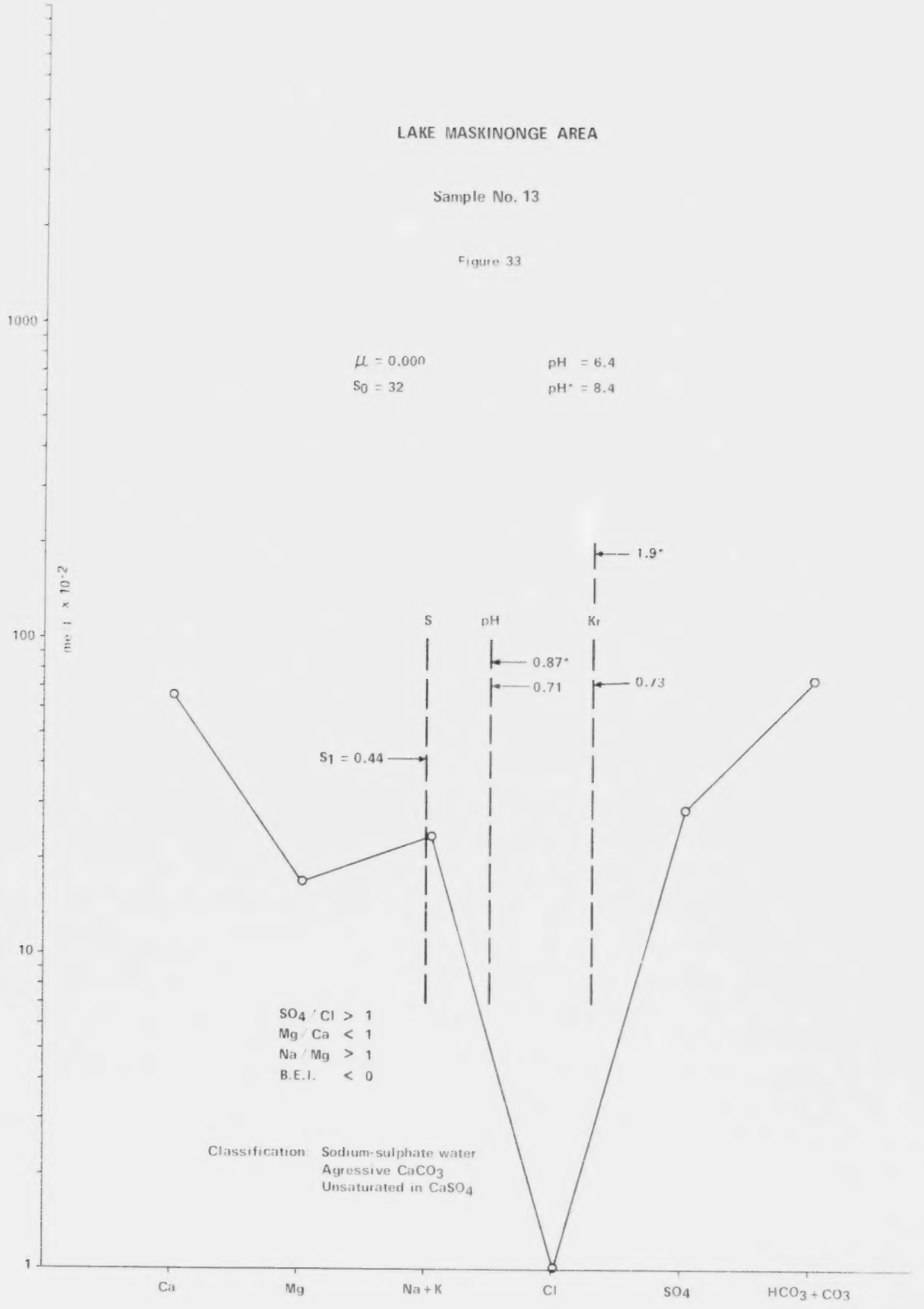
LAKE MASKINONGE AREA

Sample No. 13

Figure 33



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